

Rheology Abstracts

A Survey of World Literature

Volume 4

1961



Oxford London
New York Paris

Contents

- A. Theoretical
- B. Instruments and Techniques
- C. Metals and other Solids
- D. Polymers, Elastomers and Viscoelastic Materials
- E. Pastes and Suspensions
- F. Liquids
- G. General

Published by

PERGAMON PRESS LIMITED

for the

BRITISH SOCIETY OF RHEOLOGY

RHEOLOGY ABSTRACTS

Published by Pergamon Press Limited for the
British Society of Rheology

Hon. Editor : J. H. C. VERNON, B.Sc., Ph.D.

THE BRITISH SOCIETY OF RHEOLOGY

Officers and Committee for 1960/61

President : Professor R. W. DOUGLAS, D.Sc., F.Inst.P.

Hon. Secretary : M. F. CULPIN, Ph.D., F.Inst.P.

Hon. Treasurer : C. C. MILL, M.Sc., A.Inst.P.

Hon. Editors : J. H. C. VERNON, B.Sc., Ph.D.

J. F. HUTTON, B.Sc., A.Inst.P.

*Members of
Committee :*

G. K. JONES, B.Sc., F.Inst.Pet.

D. W. JOPLING, B.Sc., A.R.I.C.

D. R. REID, M.A.

R. ROSCOE, Ph.D., F.Inst.P.

D. W. SAUNDERS, Ph.D., A.R.C.S., F.Inst.P.

G. H. TATTERSALL, M.Sc., Ph.D., A.Inst.P.

R. W. WHORLOW, B.Sc., A.R.C.S., A.Inst.P.

P. E. KNAPP, B.Sc., F.Inst.Pet.

Publishing Offices : HEADINGTON HILL HALL, OXFORD

Telephone : Oxford 64881

Subscription : £5 per volume of 4 issues

Payment must be made in advance

Copyright © 1961 British Society of Rheology

PERGAMON PRESS LTD.

4 & 5 Fitzroy Square, London, W.1

122 East 55th Street, New York 22, N.Y.

VOL.
4
1961

RHEOLOGY ABSTRACTS

Author Index to Volume 4

- A**
- ANON., 362
 ABRIKOSOVA, M. A., 368
 ACKROYD, G. C., 41
 ACRIPOS, A., 468
 AIDA, H., 622
 AKABANE, K., 571
 AKIYAMA, T., 571
 ALBRECHT, B., 407
 ALEXANDER, J. M., 375, 531
 ALEXEENKO, V. D., 211
 ALLEN, G. S., 346
 ALLNATT, A. R., 512, 513
 AMANO, O., 579
 AMELINA, E. A., 227
 ANDERSON, J. A., 612
 ANDRADE, E. N. DA C., 417
 ANDREEVA, I. A., 258
 ANDRES, U. TS., 133
 ANDREWS, A. I., 4
 ANDREWS, E. H., 410
 ANDREWS, R. D., JR., 197
 ANDRIANKIN, E. I., 132
 ANDRUSSOW, L., 547
 ANGELESCU, E., 599
 APPS, E. A., 344
 ARAI, T., 575
 ARAKAWA, K., 573
 ARKHIPOV, A. M., 232
 ARKHIPOV, V. N., 175
 ARKOVENKO, G. I., 219
 ARMSTRONG, E. L., 88
 ARMSTRONG, L. D., 539
 ARYNOW, A., 138
 ASHWIN, B. S., 31
 ATTACK, D., 433
 AVETISIAN, I. S., 353
- B**
- BABAREKO, A. A., 254
 BABSKY, E. E., 368
 BADAMI, D. V., 447
 BANDYOPADHYAY, P. C., 438
 BARANYAI, L. J., 363
 BARENBLATT, G. I., 173, 182
 BARFIELD, R. N., 364
 BARLOW, A. J., No. 3, p. 24
 BARTENEV, G. M., 303
 BATRA, M. M., 158
 BAUDRAN, A. A., 481
 BEEVERS, R. B., 291
 BELANGER, W. J., 319
 BELLO, H. R., 465
 BELLO, J., 465
 BENSON, C. B., 365
 BERGHEZAN, A., 409
 BERTALAN, G., 70, 87
 BESTELINK, P. N., 196
 BESTUL, A. B., 278
 BHARGAVA, R. D., 494
 BIANCHI, E., 388
 BIRKGAN, A. U., 126
 BISHOP, R. L., 106
- BLACKMAN, L. C. F., 235, 236**
- BLAND, D. R., 393
 BLANDFORD, J. M., 37, 587
 BLOMGREN, G. E., 514
 BLOTT, J. F. T., 44
 BOARDMAN, G., No. 3, p. 25
 BODOIA, J. R., 28
 BOEKE, P. J., 289
 BOGUE, D. C., 20
 BOGUSLAVSKII, I. A., 223
 BOHN, L., 442
 BORODINA, L. A., 342
 BORSCHESKAIA, A. Z., 217
 BRANDT, A., 427
 BRAVINSKII, V. G., 224
 BROOKS, J., 616
 BROWN, R. L., 538
 BRYANT, G. M., 451
 BUECHE, A. M., 86, 372
 BUCHWALD, V. T., 495
 BUGLIARELLO, G., 23
 BULAVIN, I. A., 356
 BURKOV, V. A., 351
 BUTLER, L. H., 92
 BUVET, R., 488
- C**
- CAMERON, A., 29
 CAMPBELL, J. G., 519
 CAMPBELL-ALLEN, D., 496
 CAMPUS, F., 422
 CARLEY, E. L., 275
 CASE, L. C., 13
 CAW, W. A., 486
 CHAEVSKII, M. I., 262, 268
 CHAKRABARTI, R. K., 110
 CHAKRAVARTY, A., 484
 CHANG, S., 582
 CHAPPEL, F. P., 447
 CHATAIN, M., 548
 CHATTERJEE, H., 83
 CHATTERJI, A. K., 429
 CHERNIN, I. M., 272
 CHIANG, R., 593
 CHRISTENSEN, G. N., 539
 CHRISTY, R. W., 377
 CHURAEV, N. V., 97
 CIFERRI, A., 456, 560, 584, 585, 593
 CINOGRADOV, G. C., 57
 CLARKE, L. N., 48, 541, 542
 CLELAND, R. L., 482
 COHEN, M. H., 509
 COLEMAN, B. D., 460
 COLVIN, J. R., 459
 CONWAY, B. E., 317
 CORMIA, R. L., 379
 COX, M. C., 626
 COX, R. A., 472
 COX, W. F., 267
 CRYSTAL, E., 464
 CSUROS, Z., 70, 87
 CULPIN, M. F., 447
- CUMBERBIRCH, R. J. E., 79, 517**
- CURRAN, R. J., 197
 CUSACK, N. E., 118
- D**
- DAILY, J. W., 23
 DALTON, W. K., 198
 DANNHAUSER, W., 583
 DAS, S. C., 146
 DATE, M., 527
 DAVENPORT, T. C., 42
 DAVIDOVSKAIA, I. B., 325
 DAVIES, J. W., 421
 DAVIES, T. E., 293
 DAVIS, P. A. G., 483
 DE WAELE, A., 601
 DEBYE, P., 482
 DEINDOERFER, F. H., 105
 DEINAGA, J. F., 474
 DEINAGA, Y. F., 620
 DEKARTOVA, N. V., 207
 DEMKIN, N. B., 6
 DENT, R. W., 307
 DENTON, M. J., 405
 DERIAGIN, B. V., 269, 534
 DEWEY, G. H., 322
 DHAMANEY, C. P., 401
 DHARIYAL, K. D., 429
 DICK, W., 408
 DICKINSON, E. J., 339
 DIMARZIO, E. A., 505
 DISMER, K., 471
 DODGE, D. W., 113
 DOMORIAD, I. A., 222
 DONABEDOV, A. T., 136
 DOYLE, C. D., 279
 DREYER, C. J., 220, 546
 DRIESNER, A. R., 430, 431
 DRUIANOV, B. A., 155
 DUBOIS, P., 548
 DUSEMALIEV, U. K., 256
 DUKES, W. A., 286
 DUMANSKII, A. V., 620
 DUNN, J. R., 565
- E**
- EFROS, D. A., 174
 ELLIS, E. G., 115
 ELLIS, R. J., 193
 ELY, R. E., 292
 ENDERBY, J. E., 118
 ENGELTER, A. D., 408
 ENTIN, P. I., 247
 EPIFANOV, G. I., 245, 353
 ESPANION, G., 402
 ESTRIN, E. I., 248
 ESTRIN, M. I., 186
 EYDOKIMOV, V. D., 161, 167, 177, 212, 329
 EYRING, H., 19, 469.

INDEX OF AUTHORS

F

FABELINSKII, I. L., 163
 FASTOV, N. S., 129, 131
 FEDOTOV, S. C., 266
 FEIGIN, L. A., 234, 325
 FELTHAM, P., No. 1, p. 25, 420, 424
 FERRY, J. D., 443, 577, 583
 FEUGE, R. O., 478
 FEUGHELMAN, M., 78, 308, 309, 310, 311, 312, 457
 FIDLERIS, V., 398
 FINCKE, A., 400
 FINKELSTEIN, M. Z., 343
 FISCHER, L., 280
 FISHER, M. E., 592
 FITCH, E. B., 34
 FIVEISKII, M. B., 270
 FLOM, D. G., 372, 435
 FLORY, P. J., 502, 560, 588, 593
 FORD, T. F., 24
 FORRESTER, J. A., 205
 FORSTER, E. O., 94
 FOURDEUX, 409
 FRANK, R., 603
 FRANKL, F. I., 139
 FREESTON, W. D., 5
 FREUDENTHAL, A. M., 407
 FRIDMAN, I. A., 160
 FRISCH, H. L., 274
 FUJINO, K., 572, 576
 FUJISHIGE, S., 458
 FUJITA, H., 591
 FUKADA, E., 527, 528, 558, 614, 617
 FUKUDA, M., 74
 FUKUSHIMA, M., 614
 FURUYA, S., 85

G

GALAKTIONOV, V. A., 208
 GALLAGHER, J. P., 89
 GALPERIN, D. I., 580
 GAMSKE, K., 422
 GARA, M., 70, 87
 GARKUNOV, D. N., 255
 GARNER, F. H., 15
 GASKINS, F. H., 45
 GAVIS, J., 14
 GEE, G., 566
 GENENSKY, G. M., 18
 GENGRINOVICH, B. I., 304
 GHOSH, A. M., 484
 GIESEKUS, H., 384, 385
 GILL, S. S., 3
 GILLESPIE, T., 321
 GLAGOLEV, N. I., 245
 GLAZOV, V. M., 354
 GLUCK, D. F., 323
 GLUCKLICH, J., 425
 GOLD, L. W., 221
 GOLDFEIN, S., 276, 283
 GOL'DIN, S. A., 96
 GOLDSMITH, H. L., 602
 GOODMAN, F. O., 625
 GORIUNOV, Iu. V., 261, 263

GORKOVA, I. M., 537
 GOTOH, R., 101, 622
 GOYAL, S. C., 158
 GRANQUIST, W. T., 507
 GREEN, J. H. S., 201
 GRIAZNOV, G. V., 150
 GRIGORIEVA, L. F., 228
 GUDKOVA, T. I., 345, 347
 GUICE, W. A., 478
 GUL', V. E., 137, 272
 GULICK, R. A., 194
 GUNDIAH, S., 71, 306, 318
 GUNNERSON, H. L., 89
 GUPTA, R. C., 401, 540
 GUPTA, R. P., 586
 GUREVICH, G. I., 162
 GUREVICH, M. I., 121
 GUSEVA, L. N., 254
 GUTKIN, A. M., 7, 8, 9, 157, 516
 GZOVSKII, M. V., 21, 80

H

HAGYARD, T., 31
 HAHN, S. J., 19
 HALE, H. P., 616
 HALL, I. H., 288, No. 3, p. 28
 HALL, J. M., 114
 HALLETT, A. C., 365
 HALY, A. R., 309, 310, 311
 HAND, G. L., 387
 HARKER, R. J., 110
 HARPER, J. C., 487, 532
 HARRIS, J., 397
 HARRISON, G., No. 3, p. 24
 HARTLEY, P. N., 566
 HASKIN, L., 431
 HASSETT, N. J., 399
 HASTILOV, P. A. P., 225
 HAWKINS, J. G., 299
 HAYASHI, S., 11
 HEARLE, J. W. S., 307, 313
 HEINZ, W., 400
 HELLMAN, M. Y., 274
 HENWOOD, G. A., 49
 HERBERT, J. B. M., 566
 HIDESHIMA, T., 549
 HIGUGHI, M., 1
 HILEY, B. J., 499, 592
 HILL, T. L., 503
 HILLER, K. H., 50
 HILLIG, W. B., 366
 HILTON, H. H., 497
 HILYARD, N. C., No. 3, p. 30
 HIRAI, N., 469
 HIROSE, H., 621
 HIRSCHFELDER, J. O., 369
 HO, H., 624
 HOASHI, K., 556
 HOFFMANN, W., 36, 403
 HOLLINGSWORTH, C. A., 507
 HOLLOWAY, D. G., 225
 HOLMES, R., No. 3, p. 28
 HOLVE, C. A. J., 560
 HOLWECH, I., 423
 HOLZMULLER, W., 380

HOMAYR, J., 413
 HOPKINS, L. F., 77
 HORIO, M., 530
 HOSKING, D. E. M., 41
 HOTTINGER, K., 406
 HSIAO, C. C., 440
 HUGGINS, C. M., 86
 HULL, H. H., 116
 HULSE, G., 295
 HUNTER, S. C., 498
 HYNNE, R. A., 623

I

IAGN, Iu. I., 178
 ILLERS, K. H., 300
 INDENBOM, V. L., 246
 INOUE, T., 596
 ISAEV, N. I., 164
 ISHIDA, Y., 53, 550, 579
 ISHIKAWA, K., 81, 589
 ISO, K., 30
 IUDOVICH, V. I., 159, 348
 IVANOVA, V. S., 151
 ILEV, D. D., 123, 152, 172, 180, 189
 IWAYANGI, S., 555
 IYER, B. V., 315

J

JACKSON, D. S., 462
 JACOBS, H., 300, 445
 JANESCHITZ-KRIEGL, H., 147, No. 3, p. 27
 JASWON, M. A., 494
 JENCKEL, E., 445
 JERRARD, H. G., No. 3, p. 29
 JOARDER, G. K., 81
 JOHNSON, A. A., 253, 386
 JOLLIFFE, K. H., 417
 JONES, J. R., No. 1, p. 22
 JONES, J. T., 43
 JOPLING, D. W., No. 3, p. 27
 JORDAN, D. O., 62, 63, 64

K

KABANOV, V. A., 564
 KACHALOV, N. N., 228
 KAGHAN, W. S., 46, 284
 KALPAGAM, V., 595
 KAMBE, H., 606
 KAPUR, S. L., 71, 306, 318, 448
 KARAM, H. J., 59
 KARAS, G. C., 202
 KARGIN, V. A., 564
 KARIUS, H., 339
 KARPMAN, V. L., 368
 KASIANOV, N. M., 326
 KATAYAMA, M., 598
 KAUFMAN, S., 426
 KAWAGUCHI, T., 557
 KAWAI, H., 572, 576
 KAWAI, K., 38, 571
 KEEN, R. A., 205
 KEMMNITZ, G., 61, 402, 529

INDEX OF AUTHORS

KÉPÉS, M., 489
KHANNA, S. N., 448
KHIZNICHENKO, L. P., 222
KHOLMIANSKII, M. M., 233
KIM, W. K., 469
KING, J. W. H., 206
KINGSTON, R. S. T., 541, 542
KINSINGER, J. B., 501
KINTNER, R. C., 90
KIRKWOOD, J. G., 144
KISHIMOTO, A., 591
KLEMARD, E. N., 111
KLIMENKOV, V. S., 441
KLINE, D. E., 452
KNIBBS, R. H., 52
KNOWLES, J. K., 10
KOBAYASHI, T., 72
KOBÉ, K. A., 39
KOCHANOVA, L. A., 134, 258
KOGAN, M. N., 168
KOJIMA, Y., 72, 594
KOKAYASHI, A., 40
KOLBOVSKII, YU. YA., 273
KOPITSKII, CH. V., 242
KORPUT, V. M., 241, 243
KOSHLIAKOV, M. N., 351
KOSOGOV, K. F., 249
KOSTINA, T. F., 441
KOTAKA, T., 143, 434
KOTLIAR, J. M., 184
KOZAROVITSKII, L. A., 345, 347
KOZIN, V. I., 270
KOZLOV, P. V., 290
KRAGELSKY, I. V., 6
KRASOVSKII, IU. P., 127
KREMNEV, L. J., 342
KROTOVA, N. A., 269, 271
KRUM, F., 437
KUHN, W., 463, 466, 467
KULSHRESTHA, V. K., 107
KURANOV, I. F., 174
KURATA, M., 434
KURATOV, P. S., 493
KURUCSEV, T., 62, 63, 64
KUSAKOV, M. M., 359
KUZNETSOV, K. K., 162
KUZNETSOV, V. D., 239, 251, 259
KVITKOVSKII, L. N., 350

L

LABZIN, V. A., 260
LADIK, J., 51
LADYZHNSKAIA, O. A., 349
LAMB, J., No. 3, p. 24
LAMMIMAN, K. A., No. 3, p. 26
LANCELEY, H. A., 566
LAZURKIN, IU. S., 270
LEADERMAN, H., 490
LEE, E. H., 392
LENKIEWICZ, W., 428
LEVENGOD, W. C., 226
LEVI, S. M., 76
LEVIN, M. L., 419
LEWIS, D., 252

LICHTMAN, V. I., 241, 249, 257, 260
LINGE, J. R., 216
LIPSON, S. G., 405
LISHTVAN, I. I., 97
LITT, M., 544
LITVINKOV, S. S., 124
LODGE, A. S., 47, No. 3, p. 29
LOMIZE, G. M., 324
LORD, P., No. 3, p. 28
LORENZ, P. B., 148
LOSKUTOV, A. I., 239, 251
LOVELL, S. E., 443
LOWE, A. G., 41
LOZOVSKAYA, N. V., 109
LUKOMSKAIA, A. I., 156, 305
LUNDBERG, J. L., 274

M

MACK, C., 79, 517
MACKENZIE, J. D., 366
MACLENNAN, D. F., 316
MADOC JONES, D., 447
MAGARVEY, R. H., 106
MAJER, H., 463
MAJER, J., 554
MALCOLM, J. E., 390
MAL'TSOV, K. A., 232
MAMAKOV, A. A., 153
MAMES, J., 426
MAMOTANI, M., 610
MANIN, V. N., 57
MARCHENKO, I. IU., 564
MARCHESSAULT, R. N., 104
MARSH, D. M., 523
MARTIN, R. G., 44
MARTYNOV, E. G., 231
MARVIN, R. S., 117
MASON, I. B., 52
MASON, P., 119
MASON, S. G., 104, 120, 316, 602, 608, 609
MATSHINSKI, M., 382
MATSUMAE, K., 73
MATSUMOTO, M., 298
MATSUMOTO, S., 98, 610
MATSUSHITA, T., 613
MATTHEWS, A. S., 295
MATVEEV, A. K., 231
MAXIMOVA, O. P., 248
MAY, W. D., 433
MAZUMDAR, A. K., 83
MCGARRY, F. J., 197
MCGLAMERY, R. M., 289
MCKENNEL, R., 191, 192, 394
MCKENZIE, A. W., 461
MCKETTA, J. J., 39
MDIVNISHVILI, O. M., 96
MEERLENDER, G., 395
MENEFE, E., 436
MENON, C. C., 448
MERRILL, E. W., 60
MERRILL, L. J., 559
MESSERLE, H. K., 521
METZNER, A. B., 214, 275, 323

MEUMANN, H., 65
MEYER, V. E., 501
MHATRE, M. V., 90
MICHAILOV, N. W., 477, 479
MIKHAILOV, N. V., 345, 347
MIKHEEV, V. S., 266
MIKTROKHIN, N. M., 178
MILBURN, A. H., 330
MILLER, R. L., 65
MILLWOOD, R., 196
MILSOM, B. E., 531
MINTS, R. S., 210
MIRTSKHULAVA, TS. E., 169
MITCHELL, J. K., 480
MITCHELL, T. W., 78, 457
MIYAKE, A., 54
MIYAMICHI, K., 598
MOISEV, N. N., 183
MOKUL'SKII, M. A., 270
MOMOTANI, M., 98
MORIMOTO, O., 596
MOROSOV, A. S., 195
MOROZOVA, L. P., 269, 271
MORRELL, S. H., 200
MORRIS, E. L., 433
MOSER, P., 463
MOSHEV, V. V., 580
MOTTRAM, F. J., No. 3, p. 25
MUKHERJEE, S. N., 484
MUKHERJEE, S. W., 107
MUKHIN, L. K., 326
MUKHOPADHYAY, S. K., 455
MÜLLER, F. H., 408, 437
MULLER, H. G., 335
MUNK, P., 32, 396
MURAGISHI, K., 619
MURAKAMI, K., 439, 551, 562
MUSGRAVE, M. J. P., No. 1, p. 24
MUSSA, C., 58
MUZYKA, A., 506
MYSELS, K. J., 626

N

NACCI, A., 414
NAGHDI, P. M., 17
NAKADA, O., 16
NAKAGAKI, M., 56, 619
NAKAGAWA, T., 600, 613
NAKAJIMA, T., 55
NÁRAY-SZABÓ, I., 51
NARAYANAMURTI, D., 401, 540
NARDI, V., 569
NARITA, S., 69
NAUGOLYNKH, K. A., 181
NAZARKIN, L. A., 327
NEALE, R. N., 114
NEKRASOV, D. N., 359
NELSON, J. S., 4
NERSESOV, I. L., 162
NESBITT, L. B., 366
NEUMANN, H., 402
NEWMAN, S., 267
NIKITSKAIA, E. A., 358
NIKOLAEV, B. A., 340

INDEX OF AUTHORS

NINOMIYA, K., 567
 NISHIOKA, A., 73
 NISSAN, A. H., 15
 NODA, H., 95
 NOLLE, A. W., 444
 NORDON, P., 524
 NOVIKOV, A. S., 454

O

OBATA, H., 528
 OBERST, H., 442
 ODA, A., 528
 ODAJIMA, A., 552
 OGANDZANIANTS, V. G., 341
 OGAWA, S., 35, 528
 OGINO, K., 563
 OGIWARA, S., 530
 OGUCHI, N., 82
 OHIRA, M., 528
 OHYANAGI, Y., 298
 OKA, A., 35, 617
 OKANO, K., 508
 OKUAKI, S., 528
 OLDROYD, J. G., No. 1, p. 24, 381
 OLKHOVSKY, I. I., 140
 ONOGI, S., 72, 530, 594
 OOSTHUIZEN, J. C., 615
 ORTHWEIN, W. C., 17
 OSIPOV, K. A., 244
 OSOKINA, D. N., 21, 80
 OSTERLE, J. F., 28
 OUTWATER, J. O., 322
 OWEN, V. J., 604

P

PADMINI, P. R. K. L., 361
 PAISLEY, H. M., 201
 PANCHENKOV, G. M., 166
 PARK, I. K., 275
 PARKER, J., 3
 PARKER, P. M., 501
 PASSAGLIA, E., 470
 PASTONESI, S., 277
 PATAT, F., 471
 PATRUKHINA, N. I., 160
 PAVLOV, V. P., 80, 149, 153, 474, 476
 PAWLOWSKI, J., 455
 PEARSON, H. M., 545
 PEARSON, J. R. A., No. 1, p. 22
 PERTSOV, N. V., 240, 261
 PESIN, M. S., 163
 PETER, S., 475
 PETERLIN, A., 492, 590
 PETERSEN, E. E., 468
 PETICOLAS, W. L., 436
 PETROV, A. A., 350, 358
 PETRZHIK, G. G., 195
 PHILIPPOFF, W., 22, 45, 404
 PINES, B. J., 142, 185
 PISARENKO, A. P., 454
 PITHEY, E. R., No. 3, p. 28
 PLAZEK, D. J., 583
 PLESCH, D. H., 68

POPESCU, G., 599
 PRESTON, J. H., 103
 PRITCHARD, J. E., 289
 PROUD, K. J., 253

R

RABOTNOV, Y. N., 418
 RADCHIK, A. S., 161, 212, 329
 RADCHIK, V. S., 161
 RADHAKRISHNAN, T., 315
 RAJAGOPAL, E. S., 373
 RANGER, A. E., 77
 RAO, B. R., 361
 RAO, K. S., 361
 RAO, M. R., 595
 RAO, P. R., 102
 RATHNAMMA, D. V., 99
 RATNER, S. B., 190
 RAUTENBACH, R., 412
 READ, B. E., 581
 REBINDER, P. A., 227
 REE, T., 19, 469
 REHBINDER, P. A., 240, 245, 261, 477, 479
 REID, D. R., 446
 REID, W. H., 27
 REMMEV, I. U., 218
 REZNIKOVSKII, M. M., 305
 RICE, S. A., 144, 512, 513
 RICHARDS, T. LL., No. 1, p. 25
 RICHTER, J., No. 3, p. 24
 ROBERTS, J., 449
 ROBERTS, J. E., No. 3, p. 26
 ROESLER, F. C., No. 1, p. 23
 ROGGI, P. E., 296
 ROSCOE, R., No. 3, p. 25
 ROSEN, B., 432
 ROSENBERG, G. D., 331
 ROSENBLUM, V. I., 493
 ROSS, W. J., 203
 ROSSI, C., 388
 ROZHANSKII, V. N., 176, 207, 229
 ROZHKOVA, L. P., 259
 RUDNEVA, A. V., 301
 RUMIANSTEV, V. V., 170
 RUMSCHEIDT, F. D., 608, 609
 RUSSEL, R. J., 42
 RUSSELL, H. G., 497
 RUTHERFORD, P. P., 68

S

SAITO, K., 40
 SAITO, S., 55
 SAKAI, T., 613
 SAKAMOTO, R., 30
 SAMARIN, A. M., 355
 SANDIG, A., 462
 SANIN, P. I., 358
 SANZHAROVSKII, A. T., 187
 SARRAK, V. I., 247
 SAUER, J. A., 552, 559
 SAUNDERS, I. C. B., 31
 SAVITSKII, A. V., 154

SAVITSKII, E. M., 242, 256
 SAWARAGI, Y., 74
 SCANLAN, J., 565
 SCHACHAT, R. E., 414
 SCHARPINK, F. W., 522
 SCHEIDEGGER, A. E., 145
 SCHEREGA, H. A., 314
 SCHIEFER, H. F., 37
 SCHMIDT, I. W., 370
 SCHNEIDER, W. G., 364
 SCHOTT, H., 46, 284
 SCHULTE, S. A., 319
 SCHWARZL, F., 383, 490
 SCOTT, I. G., 536
 SCOTT BLAIR, G. W., 615, 628
 SEGALOVA, E. E., 141
 SEGAWA, M., 81, 589
 SEGRÉ, G., 334
 SEGUIN, H., No. 3, p. 24
 SEKIGUCHI, H., 450
 SELBY, T. W., 112
 SELLERS, E. S., 33
 SEMERCHAN, A. A., 208
 SENSHU, K., 572, 576
 SERGEEVICH, V. I., 357
 SERGIENKO, S. R., 350, 358
 SETHNA, D. N., 253
 SHADBIN, I. F., 352
 SHAH, M. J., 468
 SHALOPALKINA, T. G., 337
 SHASKOLSKAIA, M. P., 230
 SHCHUKIN, E. D., 135, 188, 257, 258
 SHEININ, S. S., 253
 SHELAT, B. R., 315
 SHELUDKO, A., 360
 SHIRAKASHI, K., 81, 82, 589
 SHKADINA, S. S., 340
 SHORR, B. F., 179
 SHOUSE, P. J., 587
 SHREINER, C. A., 209
 SHREINER, S. A., 75
 SHURKOV, S. N., 154
 SHVETSOV, V. A., 454
 SIDOROV, V. A., 136
 SIGALOVA, E. E., 227
 SILBERBERG, A., 334
 SILBERBERG, I. H., 39
 SILLETT, E., 93
 SIL'VESTROVICH, S. I., 223
 SIMS, W. D., 215
 SINGER, J. R., 415
 SINGH, H., 444
 SINIZYN, V. V., 474
 SIRENKO, A. F., 142, 185
 SKEWIS, J. D., 626
 SLESAREV, V. N., 208
 SMELAYA, N. I., 453
 SMITH, J. C., 37, 587
 SMITH, L. M., 338
 SMOLDYREV, A. E., 128
 SNOWDEN, K. U., 250
 SOBHANADRI, J., 485
 SOFER, L. M., 265
 SOKOLINA, G. A., 271
 SOKOLOV, I. B., 232

INDEX OF AUTHORS

SOMMER, H., 543
 SONE, T., 614, 617
 SPROULL, W. T., 491
 SPURR, O. K., 588
 ST. PIERRE, L. E., 86
 STARITSKII, P. G., 232
 STARODUBSTEV, S. V., 222
 STARTSEV, V. I., 265
 STEPANOVA, V. G., 580
 STEPANOVA, V. M., 229
 STEPHENSON, C. E., 196
 STIRLING, P. H., 624
 STOCKEL, I. H., 391
 STOGRYN, D. E., 369
 STOJANOVITCH, R., 374
 STRUNIN, B. M., 130
 SUBRAMANIAN, N., 102
 SUPPGER, E. W., 5
 SURNACHEVA, A. I., 259
 SURYANARAYANA, C. V., 389
 SUZUKI, I., 575
 SUZUKI, Y., 500
 SYKES, M. E., 499

T

TABATA, T., 69, 570
 TABLINO, V., 58
 TADOKERO, Y., 84
 TAKANO, M., 606
 TAKAHASHI, M., 597
 TAKAHASHI, Y., 574
 TAKAYANAGI, M., 53, 67,
 550, 556, 579
 TAKEDA, T., 30
 TALAIF, N. V., 371
 TAMADA, T., 73
 TAMAMUSHI, B., 95
 TAMURA, N., 434
 TANIGUCHI, Y., 72, 594
 TEMPEST, W., No. 3, p. 28
 THAKUR, V. M., 313
 THIEL, K., 427
 THOMAS, H. W., No. 3, p. 26
 THOMAS, L. H., 320
 THROWER, E. N., 204
 THURSTON, G. B., 378
 TIKAVYI, V. F., 328
 TILEY, P. F., 623
 TIMAREV, K. V., 136
 TIMOKHIN, I. M., 343
 TIMS, D. W., 416
 TOBOLSKY, A. V., 439
 TODD, A., 611
 TOLLENAAR, D., 533
 TOMASHOV, N. D., 164
 TOMILOVSKY, G. E., 246
 TOPOROV, YU. P., 534
 TORKHOVSKAIA, L. N., 136
 TORRE, C., 122

TOWNE, K. M., 587
 TRANTER, T. C., 447
 TRAPEZNILOV, A. A., 100,
 195, 473
 TRELOAR, L. R. G., 510, 511
 TRÉMOUROUX, L. M., 535
 TROLLOPE, D. H., 627
 TRUTER, E. V., 330
 TSCHOEGL, N. W., 520
 TULOVSKAIA, Z. D., 227
 TUNG, L. H., 285
 TURNBULL, D., 379, 509
 TUTORSKII, I. A., 453

U

UEMATSU, I., 561
 UEMATSU, Y., 558, 561
 UEMATU, T., 525
 ULLMAN, R., 506
 UMEYA, K., 605

V

VAKULA, V. L., 453
 VAKULENKO, A. A., 165
 VALLANDER, S. V., 125
 VAN DEN TEMPEL, M., 618
 VASIL'EV, D. M., 219
 VAUGHAN, L. H., 282
 VEILER, S. J., 241
 VEKILOV, I. U., 230
 VERESHCHAGIN, L. F., 208,
 213
 VERTMAN, A. A., 354, 355
 VIETH, H., 543
 VINOGRADOV, G. V., 80, 96,
 149, 153, 474, 476, 620
 VIRGIN, H. S., 464
 VISWANATHAN, N. V., 71,
 318
 VOLAROVICH, M. P., 7, 97
 VOLD, M. J., 25, 99
 VOET, A., 336
 VOL'MIR, A. S., 126
 VONG, T. S., 226
 VORONOV, F. F., 264
 VOROVICH, I. I., 348
 VOYUTSKII, S. S., 453

W

WADA, E., 508
 WADA, Y., 621
 WAGNER, P., 430, 431
 WAKELIN, J. H., 464
 WAL A. A., VAN DER, 297
 WALKER, J., 15
 WARBURTON, B., 202
 WARD, I. M., 568
 WATANABE, T., 91

WATKIN, K., 394
 WEBB, G. W., 194
 WEBER, W., 395
 WEGEMER, N. J., 470
 WEISS, A., 603
 WELLS, A. A., 421
 WEST, J. M., 105
 WESTON, D., 199
 WETTON, R. E., No. 3, p. 28
 WEYLAND, H. G., 526
 WHITE, E. F. T., 291
 WHITEMAN, I. R., 2
 WHITMORE, R. L., 398, No. 3,
 p. 25
 WHITNEY, L. P., 194
 WHITTEN, W. N., 336
 WILLIAMS, G., 581
 WILSON, A. W., 281
 WINKLER, F., 411
 WOITKEVICH, A. A., 367
 WOLFF, C., 294
 WOLKENSTEIN, M. V., 302
 WOLSTENHOLME, W. E., 296
 WOLTERS, H. B. M., 522
 WOODWARD, A. E., 552, 559
 WORRALL, W. E., 604
 WRIGHT, C. H., 203
 WYLLIE, R. G., 486
 WYLLIE, D., 33, 43

Y

YAMAFUJI, K., 550, 579
 YAMAKAWA, H., 504
 YAMAMOTO, M., 12, 53
 YAMAMURA, H., 84
 YANG, J. T., 470, 607
 YIN, T. P., 443, 577, 578
 YOSHINO, M., 67, 556
 YOUNG, T. E., 31

Z

ZAITSEV, A. A., 171
 ZAKS, S. L., 357
 ZARETSKII, E. M., 238
 ZHELTOV, I. U., 173
 ZHIGACH, K. F., 326, 343
 ZIEGLER, H., 376
 ZILOVA, T. K., 160
 ZOTOVA, K. V., 100
 ZUBOV, P. I., 75, 209
 ZUBOVA, E. V., 213
 ZUEV, I. U., 217
 ZUREK, W., 518
 ZVEREV, M. P., 441
 ZWANZIG, R., 515

RHEOLOGY ABSTRACTS

Subject Index to Volume 4

Prepared by Mr. R. J. COLE

A

Absorption, interaction and mechanical properties of lubricant layers, 241
 acacia catechuic acid, pH and viscosity, 107
 acrylic resin, compressive creep, 575
 adhesion
 of polymer, 453
 of polymer to glass surfaces, 269
 of polymer, mechanical characteristics, 271
 on washing, ground stability, 169
 adhesive(s)
 properties of gelatine films, 75
 rheology of, 401
 adsorption, effect, strength of steel melts, 249
 after effects, mathematical representation, 382
 ageing, rubber, stress-strain properties, 565
 aggregation, thermodynamics, 503
 air, filtration of rarified, 371
 Alfrey's analogy, thermal stress, 497
 All-Union Congress on Mechanics, report on rheology section, 109
 aluminium
 deformation, X-ray study, 252
 fatigue, 250
 internal friction after plastic deformation, 423
 naphthenate gels, etc., 332, 333, 337
 plasticity and deformation, 251
 amides, molecular association and viscosity, 320
 anomalous viscosity
 flow under pure mutually perpendicular shears, 153
 heat effects in, 149
 antimonides of Al, Ga and In, liquid, 354
 antimony single crystals, strained, 265
 apertures, flow of dry granules through, 538
 asbestos
 cement systems, 429
 Indian, 429
 Askangel suspensions, structure formation, 96
 asphalts
 brittle fracture, 101
 glass transition and rheological properties, 621

asphalts—*continued*
 viscoelasticity and brittle fracture, 622
 audio-frequencies, shear modulus of polymers at, 528
 austenite, phase work hardening, 248

B

Barium sulphate in polyisobutylene, 606
 Bauschinger's effect, sliding friction, 212
 bearing, crankshaft, oil film thickness in, 215
 bentonite gels, thixotropy, 91
 binary systems, viscosity calculation, 363
 biorheology and microcirculation, 628
 birefringence
 macromolecular solutions, 458
 streaming of cellulose micelles, 316
 streaming, laminar flow relaxation, 507
 streaming, soft linear macromolecules, 590
 streaming and viscosity, tobacco mosaic virus, 607
 bitumen(s)
 measuring elastic properties of, and soils, 204
 rheological properties, activated fillers, etc., 479
 road binders, characterization, 339
 rubberized, viscous and elastic properties, 338
 blood, flow of, 368, 415
 bone, properties of stressed, 220, 545, 546
 boundary
 lubrication, theory, 29
 problem of generalized hydrodynamics, 140
 brass
 a, at low temperature, creep and stress relaxation, 424
 cerium-alloyed, superplasticity, 256
 brittle
 fracture, asphalts, 101
 fracture, cracks, 182
 fracture, metal crystals, 135
 lacquers, 216

INDEX OF SUBJECTS

brittle—*continued*

- materials, thermal shock behaviour, 419
- rupture, zinc crystals, 257, 258
- bromate reaction in dough, 612
- bronze/steel rubbing, copper transfer, 255
- bubbles, entrapped, capillary flow, 104
- Burnett method, compressibility, 39
- bursting behaviour PVC pipe, 297
- butter, thixotropic behaviour and crystallinity, 614

C

- Cadmium single crystals, strength, 261
- caking of metal powders, dilatometry, 210
- calcium aluminate (mono-), strength, 227
- capillary
 - flow of bubbles through, 104
 - hysteresis, 359
 - rise of liquid, porous media, 359
- carbon black in mineral oil, rheological study, 336
- carboxymethyl cellulose solutions, viscosity, 343
- casein, breakdown of by rennin and rennet, 615
- cellophanes uncoated, mechanical properties, 84
- cellulose
 - bacterial, elasticity variations, 459
 - cotton, crystallinity, 464
 - elastic moduli, 511
 - fibres, viscoelastic properties, 81
 - in jute fibre, viscometry and processing, 83
 - micelles, streaming birefringence, 316
 - rayons, degree of polymerization, 79
 - regenerated filaments, strength loss with acid, 511
- cement testing, small specimens, 205
- ceramics, strength, 224
- cerium, elastic properties, 264
- chain(s)
 - length, square of, vinyl polymers, 501
 - stiff, intrinsic viscosity, 506
 - see also* polymer chains
- chemical reactions in flow, rate and kinetic constants, 166
- classification, rheological properties of bodies, 488, 489
- clay(s)
 - pastes, plasticity and elasticity, 481
 - plastic, flow properties by extrusion, 604

clay(s)—*continued*

- slips, thixotropic measurements, 605
- water mixtures, under pressure, 4
- coals, metamorphism and elasticity, 231
- cohesion between reinforcement and concrete, 233
- collagen fibres, elasticity, 588
- colloidal structure, stress and thixotropic recovery, 195
- compressibility factors, Burnett method, 39
- compression
 - of bar of visco-elastic dispersed system, 7
 - strength test, concrete, accelerated, 206
 - unidirectional, frictional properties, 534
- concentration dependence of flow birefringence, 147
- concrete
 - accelerated compressive strength test, 206
 - influence of water on strength, 232
 - prestressed beams, ultimate strength, 426
 - reinforcement cohesion, 233
 - slow deformation, 427
 - static fatigue, 425
 - structure and strength, 428
- contact
 - area, rough surfaces, 6
 - stresses, effective and friction, 627
- copolymers of vinylidene chloride and vinyl chloride, dielectric properties, 69
- copper
 - solutions, deformation, 254
 - transfer, bronze/steel rubbing, 255
- corrosion inhibitors, wear of metals, 238
- cotton
 - cellulose, crystallinity, 464
 - crystallite orientation and mechanical properties, 315
- crack(s)
 - on brittle fracture, 182
 - in crystals, during deformation, 134
 - micro-, in crystals during deformation, 176
- cracking
 - corrosive, and fatigue of strained material, 217
 - of ice, 221
- creep
 - compressive, acrylic resin, 575
 - data analysis for wood, 542
 - design computations, 418

INDEX OF SUBJECTS

creep—continued

- effect of uneven heating on stress, 179
- of ice, cracking activity, 221
- of ice, under compound stress, 126
- of metals, 244, 418
- of metals under simple shear, 417
- in plastics, 276
- poly-2-ethyl butyl methacrylate, 577
- properties, vinyl chloride-vinylidene chloride copolymer, 446
- and stress relaxation, α -brass, low temperature, 429
- and stress relaxation, viscous flow, 129
- and stress of wood, 541
- theory limited by self-diffusion, 377
- unsteady, solid bodies, 493
- of zinc single crystals, 260
- crystallinity
 - butter, 614
 - cotton cellulose, 464
- crystallite orientation and mechanical properties in cotton, 315
- crystal(s)
 - cracks in, during deformation, 134, 176
 - metal, brittle fracture, 135
 - properties, grinding dependence, 228
 - sodium chloride, dislocations, 229
 - strength, influence of electrolyte, 141
- cure temperature and strength, polyisoprene rubber, 301
- cutting behaviour, polytetrafluoroethylene, 40

D

- Damping loops, interpretation, 402
- definitions, review of, of non-Newtonian materials, 113
- deformation(s)
 - aluminium, X-ray study, 252
 - behaviour of rubbers, 304
 - character at yield point, 150
 - copper solutions, X-ray study, 254
 - cracks in crystals during, 134, 176
 - effect of on transition rubber-glass, 566
 - elastico-plastic, theory, 127
 - and failure of metals, 207
 - and fracture of transition metals, 386
 - heating effects on, rubber, 408
 - kinetics, flexibility of loading system, 160
 - liquid-plastic systems, 473

deformation(s)—continued

- plastic, dispersed ground, 324
- plastic, electron microscopy, 409
- plastic, internal friction aluminium, 423
- plastic and silver chloride properties, 230
- plastic of solids, 219
- plastic thermodynamics, 131
- plastic under tensile stress, 130
- and plasticity of aluminium, 251
- polystyrene and polyethylene, 440
- retarded elastic, viscosity determination, 475
- rock, earthquake recurrence law, 162
- slow of concrete, 427
- in solids, effect of nuclear irradiation, 218
- of surfaces, friction, 161
- of surfaces, surface active lubricants, 329
- very small, plastic-disperse systems
 - at, 618
 - of wood under stress, effect of moisture, 539
- degradation and failure of metals under load, 185
- die, conical, apparatus with, 280
- dielectric
 - properties, copolymers of vinylidene chloride and vinyl chloride, 69
 - properties, methacrylate polymers, 579
 - properties, phenol resin-polyvinyl butyral, 574
 - properties, polymer blends, 570
 - properties, polyoxymethylene, 581
 - properties, semi-crystalline and amorphous polymers, 550
 - relaxation phenomena, 53
- dielectricity, viscoelasticity and NMR, polymers, 54
- diethylamine-water mixtures, ultrasonic absorption, 364
- diffusion of small molecules, 388
- dilatometric method for caking of metal powders, 210
- dislocation
 - defects in glass, 226
 - in sodium chloride crystals, 229
 - microstructure of stresses in, 246
- dispersed systems
 - in pipes, pressure characteristics, 128
 - plastic non-aqueous, electrification and rheological properties, 620
 - rheology, 600
 - sedimentary rocks, thixotropy, 537
 - structure formation, 477
 - thick, yield value, 400

INDEX OF SUBJECTS

displacement
fronts in porous media; Muskat-Aronofsky model, 145
measurement, oscillator for, 535
dough, bromate reaction in, 612
drag measurements, force balance for, 49
drawing mechanism, hot, analysis of, 571
drop(s)
liquid, fall through pseudoplastics, 90
viscous liquid, oscillations, 27
wake of a moving, 106
dusty gases, viscosity, 491
dynamic(s)
of frictional compressible fluids, 122
mechanical properties, phenol resin-polyvinyl butyral, 574
mechanical properties, poly-2-ethyl butyl methacrylate, 577
mechanical studies, irradiated polyethylene, 559
modulus, Perspex, 449
testing of high polymer rigid bodies, 411
viscous fluid, theory, 124
yield stress, Perspex, 449

E

Earth, vertical crust motion, geophysical fields and geostructural elements, 136
earthquake recurrence law, rock deformation, 162
egg white
mechanical properties, 616
Weissenberg effect, 335
elastic(ity)
behaviour, polymers, swelling and H-bonding, 300
of clay pastes, 481
collagen fibres, 588
constants of paper, 519
deformation process, retarded, viscosity, 475
dynamic, staple fibres, 526
and hardness, titanium alloys, 266
inclusion problems, 494
incompressible material, oscillations of a tube of, 10
limit, steel, 422
materials, thermodynamics, 502
measurement of film, 626
media, surface waves, 495
and metamorphism of coals, 231
moduli, cellulose, 511
moduli, Terylene, 510

elastic(ity)—*continued*
properties of bituments and soils, measurement, 204
properties, cerium, 264
properties, liquid-plastic systems, 473
properties, polyoxypropylene glycols, 317
properties, proteins, 314
quartz filaments and gamma irradiation, 222
solids, stress-strain relations, 374
structure rigidity, plastic-disperse systems, 476
variations, bacterial cellulose, 459
elastomer behaviour, uniaxial stress-strain relationships, 13
elasto-plastic
deformations, theory, 127
elements, mathematical model, 2
materials, fatigue strength, 268
media, stress-strain relations, 165
electrification, plastic non-aqueous dispersed systems, 620
electrolyte, influence of, on crystal strength, 141
embedded objects, pressure on, 322
emulsification of structured liquids, 342
emulsions
oil-in-water, flow properties, 98, 610
polydisperse, viscosity, 373
engine cranking and lubricant viscosity at low temperatures, 112
entrance effects and turbulence, non-Newtonian flow, 20
epoxy resins
chlorine content and physical properties, 319
dynamic mechanical properties, 452
ethyl cellulose
gels of, plastic deformation, 80
plasticized, thermo-mechanical properties, 580
extrusion
frictionless, theory, 375
method for clay flow properties, 604
of polyethylene, flow irregularities, 46
properties, polymer melts, 275
visco-plastic dispersed masses, 516

F

Fabrics, polyvinyl chloride coated, testing, 198
failure
deformation, and metals, 207
degradation, and, metals under load, 185
of solids, mechanism, 154

INDEX OF SUBJECTS

- fat(s)
 - composition, polymorphic form and hardness, 478
 - plastic, viscoelasticity, 617
- fatigue
 - lead and aluminium, effect of air pressure, 250
 - new law of failure in metals, 151
 - static in concrete, 425
 - static, strained materials, corrosive cracking, 217
 - strength, elastoplastic materials, 268
 - strength, steel, 262
- fermentation broths, rheological properties, 105
- fibre(s)
 - bundles, mechanical breakdown, 460
 - modacrylic, recovery and apparent glass transition, 451
 - polyethylene terephthalate, molecular structure and mechanical properties, 568
 - reinforcement by glass and organic, 279
 - staple, dynamic elasticity, 526
 - tensile properties of twisted single, 307
 - textile, moisture and dynamic mechanical properties, 589
 - torsional properties of thin, 524
 - wool, mechanical properties, 308, 309, 310, 311, 312
- filament tests, static and dynamic, apparatus, 36
- fillers, activated and softeners, effect on rheology of bitumens, 479
- film(s)
 - elasticity, measurement, 626
 - glue, internal stresses, 209
 - liquid, spontaneous thinning, 360
 - lubricated, flow attainment, 28
 - oil, thickness, crankshaft bearing, 215
 - viscous, on solid in gas flow, 171
- filtration of rarified air, 371
- flexibility of loading system, deformation kinetics, 160
- flexural strength, polymethyl methacrylate, 292
- flow
 - behaviour, polyethylene, 555
 - of blood, 368
 - chemical reactions in, rate and kinetic constants, 166
 - dry granules through apertures, 538
 - of entrapped bubbles through capillary, 104
 - fluidized, of divided solids, 391
 - flow—continued
 - with free surfaces, unsteadiness, 121
 - gas, from a certain vessel, 138
 - gas, potential steady relativistic, 139
 - gas, viscous film on solid in, 171
 - gasified liquid, permeability, 174
 - highly thermoconductive, 168
 - of homogeneous fluids through rocks, 173
 - irregularities in extrusion of polyethylene, 46
 - irreversible, of rubber-like polymers, 303
 - laminar, relaxation, 507
 - lines, various rheological bodies, 146
 - of liquid hydrocarbons in porous Vycor, 482
 - liquid, in radially axial turbines, 125
 - of liquids through tubes, 405
 - in lubricated films, 28
 - measurements in closed circuits, 103
 - of non-Newtonian liquid on rotating disc, 468
 - non-Newtonian, particular, 23
 - oscillatory, in fluid-filled system, 390
 - patterns in particle beds, 399
 - plastic, Tresca's plasticity condition, 123
 - Poiseuille, of suspensions, 334
 - produced by sound, 181
 - properties of elastico-viscous liquids, 385
 - properties, whitening-water systems in roller gap, 412
 - rates, nuclear or electron paramagnetic resonance techniques, 415
 - reversible and irreversible of high M. W. materials, 380
 - on revolving disc, of visco-plastic system, 8
 - steady, of viscous fluid, 348
 - stress of metals at low temperature, 420
 - thixotropic, mechanism, 19
 - unsteady, viscous plastic fluids, 331
 - of visco-elastic liquids from tubes, 397
 - viscoplastic between rotating discs, 157
 - viscous, stress relaxation and creep, 129
 - flowmeter, recording with radioactive float, 416
 - fluid(s)
 - filled elastic system, oscillating flow, 390
 - frictional compressible, dynamics, 122

INDEX OF SUBJECTS

fluid(s)—continued

- mixing in agitated vessels, 214
- non-Newtonian, stability of, 18
- stress-optical analysis, 22, 404
- theory of dense, 512, 513
- "tunnel" model, theory, 26
- viscous, dynamics, 189
- viscous, dynamics, theory, 124
- viscous, incompressible, periodical motions, 159
- viscous, incompressible, steady motion in pipe, 349
- viscous plastic unsteady flow, 331
- viscous, steady flow, 348
- fluidity, concentration relationships for suspensions, 24
- foam, stability of, 328
- force-temperature relationship, viscoelasticity of polymers, 67
- fracture
 - brittle of asphalts, 622
 - brittle, cracks, 182
 - and deformation of transition metals, 386
 - surface, energy, 1
 - surfaces and stress waves, 410
 - testing, high-strength sheet materials, 237
- friction
 - and effective contact stresses, 627
 - internal in aluminium after plastic deformation, 423
 - internal method, use of, 207
 - rolling, hard cylinder over viscoelastic material, 433
 - rolling, of polymeric materials, 435
 - rolling, for spheres, 372
 - sliding, Bauschinger's effect, 212
 - and surface deformation, 161, 329
 - under uni-directional compression, 534
- frictional
 - compressible fluids, dynamics, 122
 - resistance, grease lubricated bearing, 110
 - shear resistance, surface active lubricants, 353
- fruit purées, viscometry, 487
- fuel oils, pumpability and laboratory testing, 41, 42, 43, 44

G

- Gamma irradiation, elasticity of quartz, 222
- gas(es)
 - dusty, viscosity, 491
 - flow, viscous film on solid in, 171

- gauge factor determination, 536
- gel(s)
 - formation in PVC pastes, 471
 - and Young's modulus, 466, 467
- gelatine
 - films, adhesive properties, 75
 - gels, rigidity factor, 611
 - structural-mechanical properties, 76
- gelation times, measuring apparatus, 203
- gelometer, transistorized Bloom, 414
- geophysical fields, geostructural elements and vertical earth crust motion, 136
- glass
 - dislocation defects, 226
 - molten, viscometry, 395
 - porosity of deformed, 432
 - quartz, strength and wetting, 50
 - silica, strength, 51
 - strength, 225
 - strengthening by organosilicon compounds, 223
 - surfaces, polymer adhesion to, 269
 - temperature, semicrystalline polymers, 267
 - transition, free-volume model, 509
 - transition and rheological properties, asphalt, 621
 - transition and viscoelasticity, polymers, 549
- glide(ing)
 - direction and surface work hardening, 167
 - line formation, mechanism, 188
- glue films, internal stresses, 209
- graft-polymerization, methyl methacrylate with rubber in emulsion, 448
- grain growth in metals, 244
- granules, dry, flow through apertures, 538
- graphical
 - method, circuitry, 520
 - representation, 370
- graphite
 - distortion of lattice in dispersion, 234
 - high temperature mechanical properties, 430, 431
 - lubricants, preparation, 325
 - properties, 235, 236
 - Young's modulus of polycrystalline, 52
- grinding process dependence of crystal properties on, 228
- ground(s)
 - dispersed, plastic deformation, 324
 - soft, dynamics, 211
 - stability, adhesion on washing, 169

INDEX OF SUBJECTS

H

- Hardening
 - of austenite, 248
 - of metals by cutting, 239
 - strain, of plastic bodies, 152
- hardness
 - and elasticity, titanium alloys, 266
 - of fats, 478
 - hot measuring techniques, 194
 - testing machines, low loads, 193
- heat
 - effects, anomalous viscosity, 149
 - transfer to non-Newtonian fluids, 323
- helium, liquid, viscosity, measurements, 365
- Hoppler consistometer, determination of secondary reaction points, 87
- humidity and temperature, textile fabrics, 543
- humus sols from peat, structural-mechanical properties, 97
- hydrocarbon(s)
 - alkyl-aromatic, etc., viscous properties, 358
 - binary mixtures, viscosity, etc., 357
 - flow of liquid, in porous Vycor, 482
 - viscosity/temperature properties, 350
- hydrodynamic(s)
 - boundary problem, 140
 - of materials of complex rheology, 381
 - properties of polyelectrolytes, 62, 63, 64
- hypersound in viscous liquids, Rayleigh line, 163
- hysteresis loops, textile materials, apparatus, 403

I

- Ice
 - creep of, under compound stress, 126
 - creep of, cracking, 221
- Igepal, endurance of polythene under tension in, 286
- impact tests, mild steel, cleavage fracture initiation, 421
- ink(s)
 - automatic control of for roto-gravure, 346
 - letterpress and offset, rheology, 344
 - rheological and printing behaviour, 345, 347
- ion exchangeability in thixotropic gels, 603
- irradiated polyethylene, dynamic mechanical studies, 559

- irradiation embrittlement, molybdenum, 253

J

- Jute fibre cellulose, viscometry and processing, 83

L

- Lacquers, brittle, 216
- laminar shear, behaviour of particles in, 120
- laminates
 - reinforcement, 279
 - structural behaviour prediction, 280
- lead fatigue, 250
- light scattering, theory, 508
- liquid(s)
 - drops, fall of through pseudoplastics, 90
 - extended hole theory, 514
 - filled cavities in solid, 170
 - flow through tubes, 405
 - molar sound velocity in, 361
 - plastic systems, rheological properties, 473
 - pressure measurement, gauge, 47
 - state, properties and problems, 118
 - structured, emulsification of, 342
 - structure and viscoelasticity, 119
 - theory of vibrational relaxation, 515
 - viscous, drop, oscillations, 27
 - viscous, hypersound and Rayleigh line, 163
- lithium
 - bromide, interaction of model peptides with water and, 465
 - stearate in *n*-heptane with *n*-alcohols, suspension stability, 99
- load(s)
 - metal breakdown process under, 142
 - time-dependent axisymmetric, response of viscoelastic shells to, 17
- loading
 - path and history, plastic materials, 3
 - system, flexibility, 160
- lubricant(s)
 - arc metals hardened by cutting with, 239
 - graphite, preparation, 325
 - layers, absorption interaction and mechanical properties, 241
 - surface active, frictional shear resistance, 353
 - surface active, surface friction deformation, 329

INDEX OF SUBJECTS

- lubricant(s)—*continued*
 - viscosity and engine cranking at low temperature, 112
- lubricated
 - bearing, frictional resistance, 110
 - films, flow attainment, 28
- lubricating
 - greases, working and performance, 93
 - metal surfaces at 100–1700°F, 111
- lubrication
 - boundary, theory, 29
 - relaxation phenomena, 94

M

- Macromolecules
 - random-walk model and ring closure, 499
 - soft linear, streaming birefringence, 590
 - solution of rod-like, normal stress, 143
 - thin rod-like, light scattering under shear, 508
 - viscosity, 547
- macroscopic
 - properties and micro-structure in paper, 544
 - theories of rheological properties, present state of, 383
- magnetization thermo-remanent, stress effects, 114
- materials
 - brittle, thermal shock behaviour, 419
 - of complex rheology, hydrodynamics, 381
 - heterogeneous, plastometry, 413
 - of high M.W., flow, 380
 - polymeric, rolling friction, 435
 - soft, stress relaxation, 525
- mechanical
 - behaviour of S.B.R. in Mooney viscometer, 567
 - behaviour, swollen polystyrene poly-(*p*-chlorostyrene), etc., 563
 - behaviour, wool fibres, 82
 - breakdown, fibre bundles, 460
 - dispersion, distortion of graphite lattice, 234
 - dynamic, properties, rubber-styrene, 73
 - properties, Cellophanes, 84
 - properties, isotactic polystyrene, 564
 - properties, polymer blends, 570
 - properties and structure, cellulose tyre cords, 462

- mechanical—*continued*
 - properties, Ziegler's polyethylene, 554
 - quantities in rheology, measuring, 406
- media
 - dense, theory of transport in, 144
 - porous, displacement fronts; Muskat-Aronofsky model, 145
- metal(s)
 - arc, hardening by cutting, 239
 - breakdown under load, 142
 - creep of, 418
 - creep of under simple shear, 417
 - crystals, brittle fracture, 135
 - deformation and failure, effects of surface active medium, 207
 - fatigue failure, new law, 151
 - flow stress of at low temperature, 420
 - grain growth and creep, 244
 - liquid, coatings, surface activity, 240
 - under load, degradation and failure, 185
 - polymorphous, plasticity of high temperature modifications, 242
 - powders, caking, dilatometry, 210
 - pressure processing, 241
 - strength, influence of surface activity, 240
 - under stress, passive state, 164
 - surface, strain hardening, 245
 - transition, deformation and fracture, 386
 - wear, effect of corrosion inhibitors, 238
- methyl cellulose, aggregation in solution, 463
- microcirculation and biorheology, 628
- microscopic structure and macroscopic properties in paper, 544
- milk, breakdown of casein, viscometric study, 615
- missiles, requirement for reinforced plastics, 281
- mixing fluid, in agitated vessels, 214
- modacrylic fibre, recovery and apparent glass transition, 451
- model
 - dynamic hard sphere, 379
 - studies in solid bodies, 21
- Mohr's stress circles, 5
- molecules, small, diffusion of, 388
- molecular
 - association and viscosity, phenols and amides, 320
 - dimensions, determination from rheological data, 492
 - statistics, vinyl polymers, 500
 - weight, materials of high, flow, 380

INDEX OF SUBJECTS

molecular weight
 distribution from rheological
 measurements on polymers, 436
 distribution and stress relaxation,
 polymers, 551
 high, systems, structure formation,
 477
 viscosity relationships, polymer solu-
 tions, 306
 viscosity relationships, polymethyl
 acrylate, 71
 viscosity relationships, polyvinyl ace-
 tate, 298
 molybdenum, irradiation embrittle-
 ment, 253
 Mooney viscometer, mechanical be-
 haviour of S.B.R. in, 567
 Muskat-Aronofsky model, displace-
 ment fronts in porous media, 145

N

Near range order, isotactic polypro-
 pylenes, 66
 network structure, viscoelastic property
 of, 11
 Newtonian liquids, suspensions of
 spherical particles in, 24
 nickel, viscosity of liquid, and alloys,
 355
 N.M.R. (nuclear magnetic resonance)
 poly (hexamethylene adipamides),
 586
 study, polydimethylsiloxane, 86
 viscoelasticity and dielectricity, poly-
 mers, 54
 non-Newtonian
 flow, entrance effects and turbulence,
 29
 flow, a particular, 23
 flow, polystyrene in toluene, 594
 flow, polyvinyl alcohol systems, 72
 flow, theory, 469
 flow, vinyl resin plastisols, 89
 fluid, stability of a particular,
 theorem, 18
 fluids, coaxial cylinder viscometer,
 532
 fluids, heat transfer to, 323
 liquid, flow of on a rotating disc, 468
 materials, review of definitions, 113
 measurements, viscometer design,
 191
 viscosity and flow birefringence,
 tobacco mosaic virus, 607
 viscosity of polymers, 470

nuclear particle bombardment, stresses
 and deformations in solids, 218
 nylon 11, properties, 299
 nylon 66
 rheological properties, surface ten-
 sion, 582
 structure, effect of extension, 447

O

Oil
 film thickness measurement in bear-
 ing, 215
 -in-water emulsions, flow properties,
 610
 water contact stability, porous media,
 341
 optical polarization studies of plastic
 deformation, 80
 organic matter, sedimentation rate, 327
 organosilicon compounds, strengthen-
 ing of glass by, 223
 oscillation(s)
 elastic, solid containing liquid, 183
 theory, viscoelastic medium, 378
 in wake of moving body, 175
 Oscillator, two-transistor for displace-
 ment measurements, 535
 oxygen, vitreous, existence of, 366

P

Pacific, deep current field of, 351
 paint, viscometry developments, 192
 paper
 elastic constants, 519
 macroscopic properties and micro-
 structure, 544
 structure and properties, 461
 tensile straining behaviour, 77
 parallel-plate plastometer, 35
 particle(s)
 axial migration of, in Poiseuille flow,
 602
 beds, flow patterns in, 399
 in laminar shear, 120
 motions in sheared suspensions, 608,
 609
 spherical, interaction in suspensions,
 398
 spherical, sediment volume of dis-
 persions, 25
 spherical, suspensions of in New-
 tonian liquids, 24
 passive state, metals under stress, 164
 peat, humus from, structural-mechani-
 cal properties, 97

INDEX OF SUBJECTS

- peptides, model, interaction of with water and LiBr, 465
- perbuna latices, flow properties, 455
- periodical motions, viscous incompressible fluid, 159
- permeability, characteristic, gasified liquid flow, 174
- perspex dynamic modulus and yield stress, 449
- petroleum solutions, rheological properties, 326
- phenol resin-polyvinyl butyral, dielectric and dynamic mechanical properties, 574
- phenols, molecular association and viscosity, 320
- pipes, dispersed systems in, pressure characteristics, 128
- plastic
 - bodies, strain hardening, 152
 - creep and rupture stresses, 276
 - deformations, electron microscopy, 409
 - deformation, internal friction, aluminium, 423
 - deformation, ethyl cellulose, 80
 - deformation, optical polarization studies, 80
 - deformation under tensile stress, 130
 - deformation, thermodynamics, 131
 - deformations, dispersed ground, 324
 - disperse systems, elastic structure rigidity, 476
 - disperse systems, mechanical properties at small deformations, 618
 - disperse systems, viscous properties, 474
 - flow, Tresca's plasticity condition, 123
 - medium, converging wave in, 132
 - medium dynamics, compressible, 186
 - pipe, extruded, performance, 283
 - potential, theory, 376
 - stress relaxation measurement, 197
 - stress-strain relationships, loading, 3
 - testing, temperature control, 196
- plasticity
 - of aluminium, deformation, 251
 - (super) of brass, cerium-alloyed, 256
 - clay pastes, 481
 - of high temperature modifications of polymorphous metals, 242
 - ideal equations, cylindrical co-ordinates, 180
 - laws, systematic departure from, 178
 - limitations of simple theory, 158
 - theory of ideal, 172
 - thyroid, gland structure, 367
- plastisols, non-Newtonian flow, 89
- plastometer (ry)
 - heterogeneous materials, 413
 - parallel-plate, fat viscoelasticity, 617
 - parallel-plate, theory, 35
- Poiseuille
 - flow, migration of particles in, 602
 - flow of suspensions, 334
 - viscosity of liquids, 102
- polyacrylonitrile, solubility and viscosity, 597, 598
- polarography, effect of viscosity
 - on diffuse current, 484
 - on half-wave potential, 484
- poly-2-ethyl butyl metacrylate
 - dynamic mechanical properties and creep, 577
 - and polyethylene oxide, mechanical properties, 578
- poly (α -olefins) and α -olefin monomers, proton magnetic resonance, 552
- polybutan-amide, physical and mechanical properties, 450
- polydimethyl siloxane
 - intrinsic viscosity-temperature coefficient, 585
 - N.M.R. study, 86
 - tension temperature coefficient, 584
 - viscoelastic dispersion, 583
 - viscosity/M.W. relations, 85
- polyelectrolytes
 - hydrodynamic properties, 62, 63, 64
 - viscosity and ionic strength, 472
- polyethylene
 - cross-linked, viscoelastic behaviour, 558
 - deformation and tensile strength, 440
 - endurance under tension in Igepal, 286
 - extrusion, thermal and shear degradation, 284
 - flow behaviour, 555
 - irradiated, dynamic mechanical studies, 559
 - melt viscosity, 285
 - melts, flow irregularities in extrusion, 46
 - oxide, mechanical properties, 578
 - oxide, viscoelastic properties, 443
 - relaxation spectra, 442
 - special test methods, 199
 - temperature coefficient of chain conformation, 593
 - tensile properties, 557
 - terephthalate, deformation of crystal films, 290
 - terephthalate, molecular structure and mechanical properties of fibres, 568

INDEX OF SUBJECTS

polyethylene—*continued*
 viscoelastic absorption in, 287
 Ziegler's, mechanical properties, 554
 poly-(hexamethylene adipamides) nuclear magnetic resonance, 586
 polyisobutene solutions, viscometry, 68
 polyisobutylene,
 barium sulphate in, 606
 solutions, normal stresses, 553
 viscoelastic behaviour, 444
 polyisoprene rubber, cure temperature and strength, 301
 polymer(s)
 adhesion to glass surfaces, 269
 adhesion, mechanical characteristics, 271
 amorphous, properties, 302
 amorphous, relaxation time, 562
 blends, mechanical and dielectric properties, 570
 chain configurations, concentration, 504
 (co-) of ethylene-butene, 289
 (co-) of methyl methacrylate and styrene, 293
 (co-) vinyl chloride, vinylidene chloride, creep properties, 446
 crystalline, fine structure and viscoelastic absorption, 556
 cutting behaviour, 40
 dynamic mechanical testing, 202
 glass temperature, semicrystalline, 267
 hard, relaxation spectra, 407
 high, bodies, dynamic testing, 411
 hysteresis, graphical evaluation, 61
 mechanical effects, reversible radiation, 270
 melts, extrusion properties, 275
 melts, rheometer for viscoelasticity, 530
 methacrylate, dielectric properties, 579
 methacrylate, tensile stress relaxation, 576
 molecule with solvent interaction, 592
 M.W. distributions from rheological measurements, 436
 M.W. distribution and stress relaxation, 551
 networks, stress-temperature relations, 560
 orientation, statistics, 505
 polydispersity, viscometry, 274
 relaxation processes and temperature, 55
 relaxation in structurally similar, 437
 rubber-like, irreversible flow, 303

polymer(s)—*continued*
 rupture, stress distribution, 272
 semi-crystalline and amorphous, dielectric properties, 550
 shear modulus at audio-frequencies, 528
 shrinking on rupture, 137
 solid, viscoelastic measurements, 527
 solutions, concentrated, viscosity, 321
 solutions, M.W./viscosity relationship, 306
 solutions, normal stress effect, 434
 solutions, plotting viscometry data, 58
 solutions, rheological properties, 57
 solutions, shear degradation, 278
 solutions, viscoelasticity and structure change, 56
 solutions, viscometric classification, 60
 solution, viscosity interpretation, 591
 spinnability, 38
 stretched chain, 273
 structures, thermomechanical transition, 548
 study, ultracentrifuge, 201
 swelling, H-bonding and elastic behaviour, 300
 vinyl, physical properties, 291
 viscoelastic behaviour and glass transition, 549
 viscoelasticity, dielectricity and NMR, 54
 wear by rubbing, 190
 polymeric acids, viscometry, 438
 polymerization, thermodynamics, 503
 polymethyl
 acrylate, solution viscosity, 318
 acrylate, viscosity/M.W. relations, 71
 methacrylate, flexural strength, 292
 polyoxymethylene, dielectric and mechanical properties, 581
 polyoxypropylene glycols, elastic properties, 317
 polypropene, thermomechanical properties and structure, 441
 polypropylene
 crystalline, viscoelasticity, 67
 isotactic, near range order, 66
 relaxation spectra, 442
 viscoelastic properties, 561
 polystyrene
 deformation and tensile strength, 440
 internal viscosity, 294

VOL.
4
1961

INDEX OF SUBJECTS

polystyrene—*continued*
 isotactic, synthesis and mechanical properties, 564
 polydispersity and stress relaxation, 439
 swollen, etc., mechanical behaviour, 563
 in toluene, non-Newtonian flow, 594
 vacuum forming of, 295
 polytetrafluorethylene cutting behaviour, 40
 polyurethane
 dynamic mechanical properties, 445
 foams, 200
 polyvinyl acetate
 viscosity/M.M. relationship, 298
 viscosity/temperature studies, 595
 polyvinyl alcohol
 non-Newtonian flow, 72
 steady flow of, 596
 tensile stress relaxation, 572
 polyvinyl chloride
 coated fabrics, tests, 198
 liquid systems, 70
 pastes, gel formation, 471
 pipe, bursting behaviour, 297
 effect of ultrasonics on crystallization and thermoelasticity, 569
 porosity of deformed glasses, 432
 porous
 bodies, filtration of rarefied air, 371
 media, capillary use of liquid, 359
 media, stability of water oil contact, 341
 media, tortuosity, 148
 powders, caking of metal, 210
 pressure
 on embedded objects, 322
 characteristics for dispersed systems, 128
 gauge for measurement of liquid, 47
 internal, in theory of solutions, 389
 processing of metals, 241
 swelling of wood, 540
 up to 100,000 atm, shearing stresses, 213
 printing behaviour and rheological properties of ink, 345, 347
 procedure X, 562
 protein
 elastic properties, 314
 hydrated, elastic-resilient-viscous, 340
 solutions, very dilute, viscometry, 32, 396
 proton magnetic resonance, poly (α -olefins) and α -olefin monomers, 552

pseudoplastic liquids, fall of liquid drops through, 90
 pumpability and laboratory testing, fuel oil, 41, 42, 43, 44

Q

Quartz filaments, elasticity and gamma irradiation, 222

R

Radiation reversible, polymer mechanical effects, 270
 Rayleigh line, fine structure and hyper-sound in viscous liquids, 163
 reinforced
 butadiene-nitrile rubber vulcanizates, structure, 454
 plastics, polyester/epoxide resin comparison, 282
 plastics, requirements for missiles, 281
 reinforcing action, glass and organic fibres, 279
 relaxation
 dielectric, phenomena, 53
 dielectric, and viscosity, 485
 phenomena in lubrication, 94
 processes, hardened steel, 247
 processes of polymers and temperature, 55
 properties, liquid-plastic systems, 473
 spectra in hard polymers, 407
 spectra, polyethylene and polypropylene, 442
 stress, and creep, viscous flow, 129
 stress, and M.W. distribution, polymers, 551
 stress, polydispersity in polystyrene, 439
 stress, soft materials, measurement, 525
 in structurally similar high polymers, 437
 thermoelastic, polyvinyl chloride, 569
 time, amorphous polymers, 562
 vibrational, theory of liquids, 515
 Reynold's equation, integrals, 184
 ribonucleic acid, viscosity and ionic strength, 472
 rigidity
 dynamic, starch solutions, 619
 factor of gelation gels, 611
 ring closure, model of macromolecule, 499
 road binders, bituminous, 339

INDEX OF SUBJECTS

- rock(s)
 - deformation, earthquake recurrence law, 162
 - dispersed sedimentary, thixotropy, 537
 - fissured, flow through, 173
- roller-gap, flow properties of whitening-water system in, 412
- rolling, hot, distortion determination, 531
- rotating disc, flow of non-Newtonian liquid, 468
- rotogravure, automatic ink control, 346
- rough surfaces, contact area, 6
- Rouse-Bueche theory of viscoelastic behaviour, 117
- rubber
 - deformation behaviour, 304
 - glass transition, effect of deformation, 566
 - heating effects on deformation, 408
 - polyisoprene, 301
 - rupture and tear, 305
 - stress-strain properties on ageing, 565
 - styrene resin, dynamic mechanical properties, 73
 - tear resistance, sample stress, 156
 - tension-temperature coefficient, 456
 - thixotropy in vibration, 74
- rubbing wear of polymers, 190
- rupture
 - shrinking of polymers on, 137
 - stresses in plastics, 276
 - and tear, in rubbers, 305

S

- S.B.R., mechanical behaviour in Mooney viscometer, 567
- seas, tideless, discontinuous currents, 352
- sedimentation
 - rate, organic matter, 327
 - volume, dilute dispersions of spherical particles, 25
- sericite suspension, flow properties, 95
- shear(s)
 - degradation, polyethylene extrusion, 284
 - degradation, polymer solutions, 278
 - laminar, particle behaviour, 120
 - light scattering of macromolecules under, 508
 - modulus, polymers, audio frequency, 528
 - mutually perpendicular, anomalous flow, 153

- sheet materials, high-strength, fracture testing, 237
- silicate melts, viscosity determinations, 356
- silver chloride, plastic deformation and rheological properties, 230
- sliding friction, Bauschinger's effect, 212
- sliplines, microstructure of stresses, 246
- soap films, torsion pendulum measurements, 100
- sodium chloride crystals, dislocations, 229
- sodium ricinoleate-*o*-cresol-sodium chloride solution, viscosity, 599
- soils
 - bitumens and tars, measuring elastic properties, 204
 - thixotropy, 480
- solid(s)
 - containing liquid, oscillations, 183
 - divided, flow of, 391
 - effect of nuclear irradiation on stresses and deformations, 218
 - elastic, stress-strain relation, 374
 - failure, mechanism, 154
 - with liquid filled cavities, equilibrium stability, 170
 - plastic deformation of, 219
 - time-dependent tensile strength of, 288
- solutions
 - theory of, 503
 - internal pressure, 389
 - nonideal applied to ultrasonic absorption, 625
- solvent interaction, polymer molecule, 592
- sound
 - flows produced by, 181
 - velocity, molar, in liquids, 361
- sphere(s)
 - model, dynamic hard, 379
 - rigid, dense fluid theory, 512, 513
 - in a viscoplastic fluid, 133
- spinnability of high polymers, 38
- splash by water drop, effect of viscosity, 483
- starch
 - solutions, dynamic viscosity and rigidity, 619
 - structures, elastic-resilient-viscous properties, 340
- steel
 - elastic limit, 422
 - fatigue strength, 262
 - low tempering of hardened, relaxation processes, 247
 - mild, notched impact tests, 421

INDEX OF SUBJECTS

steel—continued

strength in melts, adsorption effect, 249

sulphur trioxide, liquid, vapour pressure and viscosity, 623

strain

gauges, resistance, transformer bridges, for use with, 48

hardening, metal surfaces, 245

hardening, plastic bodies, 152

strained materials,

single antimony crystals, 265

static fatigue and corrosive cracking, 217

strength

of ceramics, 224

of concrete, 428

of concrete, effect of water, 232

of crystal, influence of electrolyte, 141

effect of cure temperature on polyisoprene, 301

of glass, 225

of glass with organosilicon compounds, 223

loss by cellulose filaments, 517

of monocalcium aluminate, 227

silica glass, 51

of steels in melts, adsorption effect, 249

and wetting of quartz glass, 50

stress

analysis, visco-elastic materials, 392

behaviour of thermoplastics, 277

colloidal structure and thixotropic recovery, 195

compound, creep of ice under, 126

and creep of wood, 541

distribution in polymer rupture, 272

effect of uneven heating on, creep, 179

effects on thermo-remanent magnetization, 114

internal, glue films, 209

internal, varnish coatings, 187

metals under, passive state, 164

non-linear, energy loss, 529

normal

effect in polymer solution, 434

polyisobutylene solutions, 553

in sheared viscoelastic systems, 15

in solution of rod-like macromolecules, 143

-optical analysis of fluids, 22, 404

by optical polarization, model studies, 21

oscillatory tensile, tyre cords, 65

relaxation

stress—continued

and creep, α -brass low temperature, 424

and creep, viscous flow, 129

measurements, plastics, 197

and M.W. distribution, polymers, 551

polydispersity in polystyrene, 439

polyvinyl alcohol, 572, 573

soft materials, measurement, 525

tensile, methacrylate polymers, 576

thermo-reversible gels, 573

shearing, various substances, up to 100,000 atm pressure, 213

in slip lines and dislocations, microstructure, 246

in solids, effect of nuclear irradiation, 218

state of, rubber samples, tear tests, 156

strain

properties of rubber on ageing, 565

relationship, elastic solids, 374

relations, elasto-plastic media, 165

temperature-relations, polymer networks, 560

tensile, and plastic deformation, 130

tensor for visco-elastic bodies, 384

thermal, in slabs of linear rheological material, 496

ultimate, of prestressed concrete beams, 426

waves and fracture surfaces, 410

wood under, moisture and deformation, 539

structural-mechanical properties, humus sols from peat, 97

structure

change of polymer solutions and viscoelasticity, 54

fine and viscoelastic absorption, crystalline polymers, 556

sucrose acetate isobutyrate, viscosity/temperature relationships, 362

surface(s)

deformation, friction, 161

rubbing, wear, 177

tension, Nylon 66, 582

waves in anisotropic elastic media, 495

work hardening and gliding direction, 167

surface-active

media, effect of, on stress hardening, 245

medium, deformation and failure of metals, 207

surface activity, liquid metal coatings and metal strength, 240

INDEX OF SUBJECTS

suspension(s)
 dilute, theory, 387
 sheared, particle motions in, 608, 609
 of spherical particles, physical interaction, 398
 stability of lithium stearate in solvent, 99
 swelling
 pressure of wood, 540
 and v.p. of gels, Young's modulus, 566
 synthesis, isotactic polystyrene, 564

T

Tear
 resistance, rubber sample stress, 156
 and rupture in rubber, 305
 temperature
 control in plastics testing, 196
 and humidity, textile fabrics, 543
 tensile
 properties, polyethylene, 557
 properties of single fibres, 307
 straining behaviour of paper, 77
 strength, polystyrene and polyethylene, 440
 strength of solids, time-dependent, 288
 stress and plastic deformation, 130
 testing machine, micro, 523
 testing machine, whiskers, 522
 tension-temperature coefficient
 polydimethylsiloxane, 584
 rubber, 456
 terylene, elastic moduli, 510
 textile
 fabrics, temperature and humidity behaviour, 543
 fibres, moist and dynamic mechanical properties, 589
 materials, hysteresis loops, apparatus, 403
 yarns, stress-strain relations, 587
 thermal
 conductivity and viscosity, pressure dependence, 369
 degradation, polyethylene extrusion, 284
 stresses, extension of Alfrey's analogy, 497
 stresses in slabs of materials, 496
 thermoconductive flows, 168
 thermodynamic(s)
 of aggregation of polymerization, 503
 approach to rheology, 116
 elastic materials, 502
 and plastic deformation, 131

thermoelastic relaxation in P.V.C., 569
 thermomechanical transition, structure of polymers, 548
 thermoplastics, behaviour under stress, 277
 thermo-reversible gels, stress-relaxation, 573
 Thévenin's theorem, generalization, 521
 thixotropy (ic)
 bentonite gels, 91
 behaviour of butter, 614
 coefficient, determination, 601
 dispersed sedimentary rocks, 537
 gels, ion exchangeability, 603
 lubricant, salesman's story, 115
 measurements, clay slips, 605
 recovery, colloidal structure and stress, 195
 in soils, 480
 substances, flow mechanism, 19
 in vibration, rubber, 74
 thyroid gland structure, plasticity, 367
 tin single crystals, mechanical properties, 263
 titanium alloys, indentation hardness and elasticity, 266
 tobacco mosaic virus, viscosity and flow birefringence, 607
 torsion pendulum measurements, soap films, 100
 torsional properties of wool fibres, 78, 457
 tortuosity in porous media, 148
 transition metals, deformation and fracture, 386
 transport in dense media, theory, 144
 Tresca's plasticity conditions, plastic flow, 123
 "Tunnel" model, new theory of fluids, 26
 turbines radially axial, liquid flow in, 125
 turbulence and entrance effects, non-Newtonian flow, 20
 tyre cords
 cellulose, mechanical properties and structure, 462
 under oscillatory tensile stress, 65

U

Ultracentrifuge, polymer study, 201
 ultrasonic
 absorption, diethylamine-water mixtures, 364
 absorption, theory of non-ideal solutions, 625
 radiation of P.V.C., 569

INDEX OF SUBJECTS

uniaxial stress-strain relationship, elastomer behaviour, 13

V

Vacuum forming, polystyrene, 295
vapour pressure, liquid sulphur trioxide, 623

varnish coatings, internal stresses, 187
vibration, thixotropy in, of rubber, 74
vibroscope, rotational, fibre measurement, 524

vinyl
 calendaring compounds, 296
 polymers, molecular statistics, 500
 polymers, square of chain length, 501
 resin plastisols, non-Newtonian flow, 89

visco-elastic(ity)
 absorption and fine structure, crystalline polymers, 556
 absorption in polyethylene, 287
 of asphalts, 622
 behaviour
 crosslinked polyethylene, 558
 and glass transition, polymers, 549
 nomenclature for linear, 490
 polyisobutylene, 444
 bodies, stress tensor, 384
 dielectricity and N.M.R., polymers, 54
 dispersed system, compression, 7
 dispersion, polydimethyl siloxane, 583
 force-temperature relationship, crystalline polymers, 67
 jets, propagation of transverse waves on, 14
 linear, theory, 393
 and liquid structure, 119
 liquids, flow properties, 385
 liquids, flow from tubes, 397
 material, rolling friction of hard cylinder over, 433
 material, 45
 materials, stress analysis, 392
 medium between parallel planes, oscillation theory, 378
 non-linear, theory, 16
 plastic fat, 617
 polymer melts, rheometer, 530
 properties
 of cellulose fibres, 81
 of network structure, 11
 polyethylene oxide, 443
 polypropylene, 561
 rubberized bitumens, 338
 Rouse-Bueche theory, 117

visco-elastic(ity)—*continued*
 solid polymers, 527
 solids, theory, 498
 spherical shells, response of shallow to loads, 17
 and structure change, polymer solutions, 56
 systems, normal stresses in sheared, 15

 three dimensional bodies, 12
viscometer(s)
 bar, with conical annulus, 533
 co-axial cylinder, 33
 co-axial cylinder, for non-Newtonian fluids, 532
 cone-plate, for operation to 200°C, 394
 with damped torsional oscillation, 31
 design, non-Newtonian measurements, 191
 differential, relative viscosity, 30
 Mooney, mechanical behaviour of S.B.R. in, 567
 roating spindle, interpreting data, 34

viscometry(ic)
 classification of polymer solutions by, 60
 data, polymer solutions, plotting, 58
 developments, paint, 192
 of dilute protein solutions, 32, 396
 fruit purées, 487
 high polymeric acids, 438
 polyisobutene solutions, 68
 polymer polydispersity, 274
 and processing, jute cellulose, 83
 single point, 624
 study of casein breakdown in milk, 615

visco-plastic
 dispersed masses, extrusion, 516
 dispersed system, flow on revolving disc, 8
 dispersed system, screw motion of cylinder in, 9
 flow between rotating discs, 157
 fluid, sphere in, 133

viscosity
 anomalous, heat effects, 149
 anomalous, mutually perpendicular shears, 153
 binary hydrocarbon mixtures, etc., 357
 binary systems, 363
 concentrated polymer solutions, 321
 -concentration relationship for suspensions, 24
 determination in retarded elastic deformation process, 475

INDEX OF SUBJECTS

viscosity—*continued*
 determinations in silicate melts, 356
 and dielectric relaxation, 485
 of dusty gases, 491
 dynamic, starch solutions, 619
 internal, polystyrene, 294
 interpretation, polymer solutions, 591
 intrinsic, stiff chains, 506
 intrinsic, temperature coefficient, polydimethylsiloxane, 585
 and ionic strength ribonucleic acid and polyelectrolytes, 472
 of liquid nickel and alloy with copper, 355
 liquid sulphur trioxide at low temperatures, 623
 of liquids, Poiseuille's method, 102
 of macromolecules, 547
 measurements, liquid helium, 365
 melt, polyethylene at zero shear, 285
 and molecular association, phenols and amides, 320
 /molecular weight relationships
 poly-(dimethylsiloxane), 85
 polymer solutions, 306
 polymethyl acrylate, 71
 P.V. acetate, 298
 of molten glass, apparatus, 395
 non-Newtonian, of polymers, 470
 of polydisperse emulsions, 373
 poly (methyl acrylate) solution, 318
 relative, differential viscometer for, 30
 structure, of carboxymethyl cellulose solutions, 343
 temperature properties, hydrocarbons, 350
 /temperature relationships sucrose acetate isobutyrate, 362
 test below 1 sec^{-1} , 88
 and thermal conductivity, pressure dependence, 369
 of water, effect of dissolved air, 486
 Volarovich, Prof. M. P., appreciation on 60th birthday, 108
 Vycor, flow of liquid hydrocarbons in porous, 482

W

Wake of a moving
 body, oscillations, 175
 drop, 106
 water
 drop falling into glycerol/water, 483
 effect of dissolved air on viscosity, 486

water—*continued*
 oil contact stability, porous media, 341
 wave(s)
 converging, in plastic medium, 132
 transverse, propagation of on viscoelastic jets, 14
 waxes, wool grease, 330
 wear
 of metals, effect of corrosion inhibitors, 238
 of polymers, rubbing, 190
 rubbing surfaces, 177
 wedge plastically inhomogeneous, limit equilibrium, 155
 Weissenberg effect, egg white, 335
 wetting and strength of quartz glass, 50
 whiskers, tensile testing machine for, 522
 whitening-water systems, in a roller gap, 412
 wire-drawing, yield point lowering, 243
 wood
 analysis of creep data, 542
 stress and creep, 541
 under stress, deformation and moisture, 539
 swelling pressure, 540
 wool
 fibres
 mechanical properties, 308, 309, 310, 311
 torsional properties, 78, 457
 in water, mechanical behaviour, 82
 grease waxes, 330
 work hardening of surface, 167
 working and performance, greases, 93

X

X-ray
 diffraction study, copper solutions, 254
 microbeam study, aluminium deformation, 252

Y

Yarn(s)
 breakage of twisted, 313
 continuous-filament, properties, 518
 stress-strain relationships, 37, 587
 yield point
 deformation character at, 150
 lowering, wire drawing, 243
 thick disperse systems, 400

INDEX OF SUBJECTS

yokan (pasty food) rheology, 613
 Young's modulus
 polycrystalline graphite, variation
 with temperature, 52
 relations of to swelling and vapour
 pressure of gels, 466
 two kinds for gels, 467

Z
 Ziegler's polyethylene, mechanical properties, 554
 zinc
 heat treatment and properties, 259
 single crystals
 creep, 260
 rupture, 257
 strength, 261

LIST OF JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

Advanc. Polym. Sci.
Ann. N. Y. Acad. Sci.
Arch. Rat. Mech. Anal.
A.S.L.E. Trans.
A.S.T.M. Bull.

Brit. Chem. Engng.
Brit. J. Appl. Phys.
Brit. Plast.

Canad. J. Chem.
Canad. J. Phys.
Chem. Rev.
Current Chem. Papers

Dairy Ind.
Dokl. Akad. Nauk SSSR

Engineer, Lond.
Engineering, Lond.

Faserforschung
Food Tech.

Helv. Chim. Acta

Industr. Engng. Chem.
Instrum. Pract.

J. Amer. Ceram. Soc.
J. Amer. Chem. Soc.
J. Amer. Concr. Inst.
J. Amer. Inst. Chem. Engrs.
J. Amer. Oil Chem. Soc.
J. Appl. Chem.
J. Appl. Phys.
J. Appl. Polym. Sci.
J. Chem. Phys.
J. Chem. Soc.
J. Colloid Sci.
J. Dairy Res.
J. Dairy Sci.
J. Fd. Sci.
J. Inst. Petrol.
J. Mech. Phys. Solids
J. Oil Col. Chem. Ass.
J. Phys. Chem.
J. Polym. Sci.
J. Res. Nat. Bur. Stand.

J. Sci. Fd. Agric.
J. Sci. Industr. Res.
J. Sci. Instrum.
J. Soc. Dy. Col.
J. Text. Inst.

Khim. i Tekhnol. Topliva
Kolloidnyi Zh.

Lab. Pract.
Lubric. Engng.

Mod. Plast.

Nature, Lond.
N.L.G.I. Spokesman

Paint Tech.
Petrol. Engr.
Petrol. Refin.
Petroleum, Lond.
Phil. Mag.
Phil. Trans.
Phys. Fluids
Plastics, Lond.
Polymer
Proc. Camb. Phil. Soc.
Proc. Phys. Soc. Lond.
Proc. Roy. Soc.
Process Control

Quart. Appl. Math.

Research, Lond.
Rev. Matér. Constr.
Rev. Mod. Phys.
Rev. Sci. Instrum.
Rheol. Acta

Sci. Lubric.
S.P.E.J.

Text. Res. J.
Trans. Brit. Ceram. Soc.
Trans. Faraday Soc.
Trans. Plast. Inst., Lond.
Trans. Soc. Rheol.

Zement-Kalk-Gips
Z. Phys. Chem., Frankfurt
Z. Phys. Chem., Lpz.

VOL.
4
1961

Section A

THEORETICAL

1. The energy of the fracture surface. M. HIGUCHI, *J. Japan Soc. Test Mats.*, 1960, 9, 336-340. The Research Institute for Applied Mechanics, Kyushu University, Fukuoka. Energy liberated in the fracture region of a visco-elastic specimen before fracture occurs will cause a change in viscosity and extensibility, and affect the depth of the fracture surface. Fracture patterns are discussed in terms of a theory which takes into account thermal effects near the crack. [Japanese, English summary] J.V.

2. A mathematical model depicting the stress-strain diagram and the hysteresis loop. I. R. WHITEMAN, *J. appl. Mech.*, 1959, 26, 95-100. A model is made up of elasto-plastic elements, all of which have the same value of Young's modulus E , but which have different values of yield stress. It is shown that the dimensionless tangent-modulus graph E_t/E represents the cumulative frequency-distribution of those elements which are in the elastic region. From the frequency distribution, the equations for the stress-strain diagram and the hysteresis loop can be written.

Author

3. Plastic stress-strain relationships : some experiments on the effect of loading path and loading history. S. S. GILL and J. PARKER, *J. appl. Mech.*, 1959, 26, 77-87. Tests have been made on thin closed-ended tubes of alpha-brass subjected to various combinations of torque and internal pressure. The effect of loading, unloading, and reloading along different loading paths has been investigated, including the effect in the shape of the yield surface, and the form of the curve of representative stress and representative strain. The behaviour of the material for initial loading suggests that the material is isotropic in the plane of the surface of the tube but is anisotropic in a radial direction. A form of yield criterion and representative stress which correlates these results has been deduced, but the results of the tests for the second loadings of the specimens cannot be correlated in terms of a nested set of similar yield surfaces. The evidence for or against the existence of corners or pointed vertices on the yield surface is inconclusive.

Author

4. Rheological properties of the clay-water system under pressure. J. A. NELSON and A. I. ANDREWS, *Bull. Amer. ceram. Soc.*, 1959, 38, 447-455. Equipment is described for determining the forces required to shear plastic clay within its own structure or to bring about slip or a combination of slip and shear at a clay-metal interface at varying pressures and speeds. The method employs either a smooth or a splined metal rod with provision for measuring the applied torque as it rotates in plastic clay in a closed system. Apparatus to measure the pressure exerted by plastic clay when it is acted on by the externally applied force is also described. Curves for several clays show the relationship of torque requirements to clay pressure and speed of rotation of the rod under conditions when clay sheared on clay or when slip could take place at the interface. The torque requirements increased with increase in pressure and then became practically constant at a pressure depending on the water content of the clay. In general the torque required also increased with speed.

Author

SECTION A

5. A note on Mohr's stress circles. W. D. FREESTON and E. W. SUPPGER, *J. Franklin Inst.*, 1959, **268**, 106-110. A simple demonstration is presented, based on the use of the generalized co-ordinates φ and θ , of the Mohr stress-circle construction for the general three-dimensional state of stress. Results are plotted and tabulated, to show the relation between the two co-ordinates φ , θ of points on the element chosen and the two co-ordinates σ , τ of the associated points in the stress plane.

Author

6. Contact area of rough surfaces. I. V. KRAGELSKY and N. B. DEMKIN, *Wear*, 1960, **3**, 170-187. Institute for Machine Study, Academy of Sciences of the U.S.S.R. Moscow. To date the only method of calculating the contact area of two elastically deformed bodies having a curvilinear shape (Hertz formula) has assumed that these bodies are absolutely smooth. The contacting process of rough and wavy surfaces has been analysed using three contact areas: apparent, contour and real. A unit protrusion is visualized as a cone with a spherical top. Initially the spherical top is elastically deformed and plastic deformation of the flattened and truncated cone then follows. As deformation proceeds further contacting protrusions appear on the spherical and cylindrical waves and result in an increase of the contact area. A formula is deduced enabling real contact area to be calculated as a function of load, surface geometry and material properties.

P.L.L.

7. The compression of a visco-elastic dispersed system in the form of a rectangular bar. M. P. VOLAROVICH and A. M. GUTKIN, *Kolloidnyi Zh.*, 1960, **22**, 543. Kalinin Peat Institute, Moscow. The unilateral compression of a bar-shaped visco-plastic dispersed system obeying the Shvedov-Bingham equation has been examined. The bar, of rectangular cross-section, was compressed between two rigid plates, in the absence of slip. Determinations were made of the velocity and pressure distributions during the process for not very small velocities. The compression force required for the plates to approach each other at a given velocity has been calculated. [Russian. English abstract]

Author

8. Flow of a visco-plastic dispersed system on a revolving disc. A. M. GUTKIN, *Kolloidnyi Zh.*, 1960, **22**, 573. Moscow Inst. of Thermodynamics. The velocity distribution in a visco-plastic system on a revolving disc has been determined. A correlation has been found between the flow, rotation speed and medium parameters. [Russian. English abstract]

Author

9. Screw-motion of a cylinder in a visco-plastic dispersed system. A. M. GUTKIN, *Kolloidnyi Zh.*, 1960, **22**, 569. Moscow Inst. of Thermodynamics. The distribution of velocities in a visco-plastic medium caused by the screw motion of a cylinder has been determined. A relation has been found between the torque and axial force acting on the cylinder and the velocity components of the screw motion of the cylinder. A method has been proposed for the experimental determination of the yield-value and visco-plasticity from the screw motion of the cylinder in a visco-plastic dispersed system. [Russian. English abstract]

Author

10. Large amplitude oscillations of a tube of incompressible elastic material. J. K. KNOWLES, *Quart. Appl. Maths.*, 1960, 18, 71-77. California Institute of Technology. The paper treats the dynamic problem of axially symmetric oscillations of an infinitely long circular cylindrical tube of incompressible elastic material. The symmetry of the motion and the condition of incompressibility combine to permit the reduction of the problem to one to which the methods of the theory of non-linear vibrations of single-degree-of-freedom systems can be applied. Author

11. Viscoelastic property of network-structure. S. HAYASHI, *J. Japan Soc. Test Matls.*, 1960, 9, 250-254. Gumma University, Maebashi. A molecular theoretical investigation of the properties of amorphous polymers in the long relaxation time range, using the temporarily cross-linked model. Two energy dissipation processes are discussed, one due to chain slipping and one to the change in the number of chains. The theory is applied to steady tensile elongation, simple shear, and stress relaxation. [Japanese, English summary] J.V.

12. Viscoelasticity of three dimensional bodies. M. YAMAMOTO, *J. Japan Soc. Test Matls.*, 1960, 9, 255-259. Tokyo Metropolitan Univ., Tokyo. The phenomenological theory of the behaviour of Maxwell and Voigt bodies is extended to three dimensional non-linear cases. The extended Maxwell model accounts for the Weissenberg effect, and the extended Voigt model accounts for the Poynting effect. [Japanese, English summary] J.V.

13. Elastomer behaviour II. Uniaxial stress-strain relationships. L. C. CASE, *Makromol. Chem.*, 1960, 39, 119-139. Dept. Chem. Engineering, Purdue University, Lafayette, Indiana, U.S.A. Tension-elongation relations are derived for a network of Gaussian chains on the basis of various combinations of assumptions differing from and replacing that of affine deformation. A suitable choice of values for two parameters enables one of these relations to be fitted to Treloar's data on rubber for elongations up to rupture. A.S.L.

14. Propagation of transverse waves on viscoelastic jets. J. GAVIS, *Industrial and Engineering Chemistry*, 1959, 51, 885-886. Dept. of Chemical Engineering, John Hopkins University, Baltimore, Md.

15. Normal stresses in sheared viscoelastic systems. F. H. GARNER, A. H. NISSAN and J. WALKER, *Industrial and Engineering Chemistry*, 1959, 51, 858-859. The University, Edgbaston, Birmingham, 15.

16. Phenomenological theory of non-linear viscoelasticity. O. NAKADA, *J. Japan Soc. Test Matls.*, 1960, 9, 260-263. Hitachi Central Research Lab., Kokubunji, Tokyo. A non-linear response function is related to a time dependent excitation function. Initial assumptions account for causality, convergence, and stationariness. [Japanese, English summary] J.V.

17. Response of shallow viscoelastic spherical shells to time-dependent axisymmetric loads. P. M. NAGHDI and W. C. ORTHWEIN, *Quart. Appl. Maths.*, 1960, 18, 107-121. University of California, Berkley, California.

SECTION A

18. A general theorem concerning the stability of a particular non-Newtonian fluid. G. M. GENESKY, *Quart. Appl. Maths.*, 1960, **18**, 245-250. Mathematics Division, The Rand Corporation. Rayleigh proved that for an inviscid fluid the existence of a point of inflection in the velocity profile of a steady one-dimensional basic flow is a necessary condition for the growth of a superimposed two-dimensional disturbance. It is the intention of the present paper to prove a similar theorem for a particular non-Newtonian fluid suggested by R. S. Rivlin. Author

19. Flow mechanism of thixotropic substances. S. J. HAHN, T. REE and H. EYRING, *Industrial and Engineering Chemistry*, 1959, **51**, 856-857. University of Utah, Salt Lake City, Utah. Thixotropy is explained by postulating transformation of molecules between an entangled state and a disentangled state as a result of stress. R.H.B.

20. Entrance effects and prediction of turbulence in non-Newtonian flow. D. C. BOGUE, *Industrial and Engineering Chemistry*, 1959, **51**, 874-878. University of Delaware, Newark, Del. The developing velocity profile at the entrance of a pipe is studied mathematically as a means of predicting pressure drops and entrance lengths. R.H.B.

21. Model-studies of rheological processes in solid bodies with determination of stress by optical polarization. M. V. GZOVSKII and D. N. OSOKINA, *Kolloidnyi Zh.*, 1960, **22**, 560. Shmit Inst. of Earth Physics, Acad. Sci. U.S.S.R., Moscow. Use of similarity principle for studying numerous structures. Relations are found between stress-optical behaviour and deformability. [Russian. English abstract] G.W.S.B.

22. Stress-optical analysis of fluids. W. PHILIPPOFF, *Industrial and Engineering Chemistry*, 1959, **51**, 883-884. The Franklin Institute, Philadelphia, Pa. Flow birefringence data are shown to support the concept of elastic stress in flowing liquids. R.H.B.

23. A particular non-Newtonian flow. J. W. DAILY and G. BUGLIARELLO, *Industrial and Engineering Chemistry*, 1959, **51**, 887-888. M.I.T., Cambridge, Mass. Discusses the flow of dilute fibre suspensions in transparent vertical pipes of two different sizes. R.H.B.

24. Viscosity-concentration and fluidity-concentration relationships for suspensions of spherical particles in Newtonian liquids. T. F. FORD, *J. Phys. Chem.*, 1960, **64**, 1168. Dairy Products Laboratory, Eastern Utilisation Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C. Equations relating relative viscosity and relative fluidity to the volume concentration for suspensions of rigid spherical particles are listed, and data previously published by other authors are analysed. It is shown that for low and moderate concentrations the first order reciprocal to Einstein's equation gives a better description of fluidity measurements than the equation itself does of viscosity measurements. I.H.H.

VOL.
4
1961

THEORETICAL

25. The sediment volume in dilute dispersions of spherical particles. MARJORIE J. VOLD, *J. Phys. Chem.*, 1960, **64**, 1616. Department of Chemistry, The University of Southern California, Los Angeles, California. A digital computer has been used to simulate the formation of a sediment by successive deposition of equally sized spherical particles. The sediment density depends critically on the probability that two spheres cohere on contact, provided that the cohesion probability is lower than about 0.35. For higher cohesion probabilities, sediment density is not a sensitive measure of particle interaction. Although the properties of a sediment generated in this way are in good accord with physical model systems such as micron sized glass beads, colloidal systems with at least nearly spherical particles yield sediment densities almost 10 times lower than this model allows. A model is needed which takes both flocculation and sedimentation into account simultaneously. Author

26. A new theory of fluids: the "tunnel" model. Aust. J. Chem., 1960, **13**, 187 (via *J. Sci. Industr. Res.*, 1960, **19A**, 575). A new theory of fluids has been proposed which gives a better approximation to the properties of the hard-sphere fluid. It retains the basic concept of the cell theory of Hirschfelder, Curtiss and Bird by using subsystems chosen as lines of molecules moving almost one-dimensionally in tunnels, the walls of the tunnels being formed by the neighbouring lines of molecules. The procedures involved in applying the tunnel model to real fluids are closely analogous to those used by Lennard-Jones and Devonshire in using the cell model. W.G.C.

27. The oscillations of a viscous liquid drop. W. H. REID, *Quart. Appl. Maths.*, 1960, **18**, 86-89. Brown University. In his discussion of the effect of viscosity on the small oscillations of a liquid globe, Lamb observed that the results obtained in the limiting case of "small viscosity" are independent of the nature of the forces which produce the tendency to the spherical form. When these forces are due to self-gravitation, the problem has been solved by Lamb and by Chandrasekhar for arbitrary values of the viscosity. It is here shown that when these forces are due to surface tension the results obtained are identical with those obtained by Lamb and Chandrasekhar for a self-gravitating globe. Author

28. On the attainment of fully developed flow in lubricated films. J. R. BODOIA and J. F. OSTERLE, *Wear*, 1960, **3**, 165-169. Bettis Atomic Power Division, Westinghouse Electric Corporation and Department of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa (U.S.A.). A numerical analysis has been made of the development of flow in the inlet region of a stepped slider bearing. The profile development length has been determined and the pressure defect resulting from the consideration of inertia effects has been established. With typical bearing dimensions and (presumably) conventional lubricants the effect of inertia on the pressure distribution is small and the customary assumption of its negligible importance is considered justified. P.L.L.

29. A theory of boundary lubrication. A. CAMERON, *ASLE Transactions*, 1960, **2**, 195-198. Mechanical Engineering Department, Imperial College of Science & Technology, London, S.W.7. The mechanism of boundary

SECTION A

friction is assumed here to be due to the molecular forces between hydrocarbon molecules adsorbed on the surfaces rather than to welding and tearing of the opposing surface roughness. On this assumption the frictional force, which arises when two orientated layers are moved over each other, can be calculated. The formulae for the Van der Waals and the repulsion forces are those successfully used by Müller for paraffins. The different values of the kinetic and static frictions can be explained by the forces being due to the tails of the chains in kinetic and the sides of the chains in static lubrication. The value of the coefficient of friction, as calculated by this method, is of the correct order of magnitude.

Author

Section B

INSTRUMENTS AND TECHNIQUES

30. A differential viscometer designed to measure the relative viscosity. R. SAKAMOTO, K. ISO and T. TAKEDA, *J. Japan Soc. Test. Matls.*, 1960, **9**, 313-320. Tokyo University, Tokyo (Tokyo Institute of Technology, Tokyo). The viscometer consists of two concentric cylinder viscometers on the same axis. The upper one contains solvent and the lower one solution. The lower inner and upper outer cylinders are connected. The lower outer cylinder is driven; the speed of the inner upper cylinder indicates relative viscosity. [Japanese, English summary] J.V.

31. Viscometers having damped torsional oscillation. B. S. ASHWIN, T. HAGYARD, I. C. B. SAUNDERS and T. E. YOUNG, *J. Sci. Instrum.*, 1960, **37**, 480-485. Dept. of Chemical Engineering, Univ. of Canterbury, Christchurch, New Zealand. Two types of torsional pendulum viscometers, having only one solid-fluid boundary, have been developed specifically for use in fluidised solids investigations. They may have utility also in coarse or fibrous suspensions or in melts at high temperatures. The theory of these viscometers is discussed and empirical correlations are presented whereby any instrument of these two types may be used with minimal or no calibration. Author

32. The viscosimetry of very dilute protein solutions. P. MUNK, *Coll. Trav. Chim. Tches.*, 1960, **25**, 2715-2719. Inst. Macromolecular Chemistry, Czech. Academy of Science, Prague. A new method of correcting for errors due to surface tension and wall effects arising from adsorbed solute is proposed; it is assumed that the errors are independent of solute concentration. Two capillary viscometers for liquids prone to frothing are described. A.S.L.

33. The measurement of flow properties by co-axial cylinder viscometer. E. S. SELLERS and D. WYLLIE, *J. Inst. Petrol.*, 1960, **46**, 183-188. University of Wales, Swansea. The use of co-axial cylinder viscometers of both the constant shear rate and constant shear stress types is described. The results obtained with these instruments on fuels at temperatures at which they exhibit marked non-Newtonian properties are given. Straight line relationships are found when the viscosity of the fuel is plotted against the reciprocal of the rate of shear, the time of shearing being kept constant. The slopes of these straight lines varies with the time of shearing whereas the intercept on the viscosity axis is a constant for any given temperature. A.D.B.

34. Interpreting rotating spindle viscometer data. E. B. FITCH, *Industrial and Engineering Chemistry*, 1959, **51**, 889-890. Westport Laboratories, Dorr-Oliver Inc., Westport, Conn.

35. Theory of parallel-plate plastometer. S. OKA and S. OGAWA, *J. Japan Soc. Test Maths.*, 1960, **9**, 321-324. Dept. of Physics, Tokyo Metropolitan University, Tokyo. The theory is developed for a Bingham material when the specimen is larger than the plates (constant area case) and the plates are larger than the specimen (constant volume case). [Japanese, English summary] J.V.

36. Description of an apparatus for static and dynamic filament tests. W. HOFFMANN, *Faserforschung*, 1960, **11**, 433-443. Farbenfabriken Bayer A.G., Leverkusen, Germany. An apparatus for measuring force-elongation relations is described. Data are given for perlon single filaments and for viscose cord yarn. (With discussion.) [German] A.S.L.

37. Stress-strain relationships in yarns subjected to rapid impact loading. Part VI. Velocities of strain waves resulting from impact. J. C. SMITH, J. M. BLANDFORD and H. F. SCHIEFER, *Text. Res. J.*, 1960, **30**, 752-760. National Bureau of Standards, Washington 25, D.C. When a textile yarn is impacted transversely, strain waves and transverse waves which travel outwards away from the point of impact are initiated. Each strain-wave front travels at constant velocity. A transverse wave front, however, changes its velocity each time it meets a reflected strain wave front. This effect forms the basis of a new method used to measure strain-wave propagation velocities in a selection of textile yarns. Velocities obtained in this way are in good agreement with velocities obtained by two other methods. These velocities range in values from 1400 m/sec. for undrawn nylon to 5000 m/sec. for high tenacity rayon and glass fibres. Author

38. The spinnability of high polymers. K. KAWAI, *J. Japan Soc. Test Maths.*, 1960, **9**, 278-282. Kurashiki Rayon Co., Ltd., Kurashiki. An account is given of the way in which spinnaret hole diameter, extrusion rate and liquid viscosity are chosen to give a suitable coagulation time for spinning. Other factors to be considered are surface tension, ballooning, and shear dependance of viscosity; a large shear dependance will tend to cause broken threads. [Japanese, English summary] J.V.

39. Determine compressibility factors by using the Burnett method. I. H. SILBERBERG, K. A. KOBE and J. J. MCKETTA, *Industrial and Engineering Chemistry*, 1959, **51**, 1325. University of Texas, Austin, Tex. With only measurements of pressure and temperature the Burnett method may be utilised to obtain precise P-V-T data. R.H.B.

40. On the cutting behaviour of high polymers. 1. Some observations in polytetrafluoroethylene cutting. A. KOKAYASHI and K. SAITO, *J. Japan Soc. Test Maths.*, 1960, **9**, 345-352. Electrotechnical Laboratory, Manufacture Division, Tokyo. Many diagrams and photographs are given showing the effect of rake angle, relief angle, depth of cut and cutter speed on the cutting of PTFE. [Japanese, English summary] J.V.

SECTION B

41. The development of a test to predict the pumpability of Admiralty furnace fuel oils. G. C. ACKROYD, Miss D. E. M. HOSKING, A. G. LOWE, *J. Inst. Petrol.*, 1960, **46**, 189-199. Dept. of Scientific and Industrial Research. The work briefly described in this paper covers the co-operative activities of a number of laboratories over several years. The object of the work was to devise a laboratory test to enable the flow properties of Admiralty furnace fuel oil to be specified. Having determined, by a pour point procedure the conditions of oils in Admiralty storage a test known as Method VII based on pour point was developed to enable the condition of oils after prolonged storage to be predicted at the time of preparation of the oil at a refinery. Further work, including full-scale pumping trials in a pipeline of 14 to 18 inches diameter, showed that the pumping characteristics of an oil in storage could best be evaluated by a test involving the determination of the viscosity of the oil. A survey was therefore made of the flow properties of oils in storage at Admiralty depots using a coaxial cylinder viscometer. Based on his data, heat treatment procedures were investigated and eventually method XV was evolved which satisfactorily predicted the viscosities which the oils attained in Admiralty storage. Finally, storage trials were made over two and half years on freshly prepared oils, when it was found towards the end of the second year the viscosities of the stored oils approached those predicted by Method XV. Author

42. The full-scale pumping of Admiralty fuel oil and its relation to laboratory tests. T. C. DAVENPORT and R. J. RUSSEL, *J. Inst. Petrol.*, 1960, **46**, 143-160. The British Petroleum Co. Ltd.

43. The study of fuel oil pumpability using a laboratory pumping rig. D. WYLLIE and J. T. JONES, *J. Inst. Petrol.*, 1960, **46**, 161-176. Admiralty Oil Laboratory, Brentford, Middlesex.

44. The falling sphere pumpability test for boiler fuel. J. F. T. BLOTT and R. G. MARTIN, *J. Inst. Petrol.*, 1960, **46**, 208-216. "Shell" Research Ltd. A method of determining the temperature at which a residual oil will have a specified viscosity is described which is simple, comparatively quick, and needs only easily obtained apparatus. Various factors affecting the test are discussed, with the conclusion that no elaborate precautions need be taken in adjusting the apparatus. Author

45. Rheological investigation of viscoelastic materials. F. H. GASKINS and W. PHILIPPOFF, *Industrial and Engineering Chemistry*, 1959, **51**, 871-873. Laboratories for Research and Development, Franklin Institute, Philadelphia, 3, Pa. Describes instruments in use in the Franklin Institute Laboratories.

46. Flow irregularities in the extrusion of polyethylene melts. H. SCHOTT and W. S. KAGHAN, *Industrial and Engineering Chemistry*, 1959, **51**, 844-846. Olin Mathieson Chemical Corp., New Haven 4, Conn. A commercial screw extruder and special dies were used to study the factors which promote the occurrence of irregularities. R.H.B.

47. Low-compliance diaphragm-capacitance gauge for measurement of liquid pressures of the order of 1 in. water. A. S. LODGE, *J. Sci. Instrum.*, 1960, 37, 401-403. British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22. The construction of a compact "diaphragm-capacitance" gauge is described, which is suitable for pressure measurement in flowing polymer solutions of appreciable viscosity. Sensitivities in the range 1 to 12 pF/in. water are obtained by using different diaphragm units, and the overall zero stability is about 0.002 in. water over a few hours. The response time is about 5 seconds when the gauge is filled with a 50P liquid and the outlet hole is 0.5 mm. in diameter and 2 mm. in length. Author

48. Transformer bridges for use with resistance strain gauges and similar transducers. L. N. CLARKE, *J. Sci. Instrum.*, 1960, 37, 381-384. Division of Forest Products, C.S.I.R.O., Melbourne, Australia. A method of balancing a.c. bridges having transformer ratio arms is described which is particularly suitable for use with resistance transducers such as electrical-resistance strain gauges. The long-time stability and accuracy of readings can be readily made better than required for most static testing by the use of an auxiliary transformer. The bridge can be combined with a commercial potentiometric recorder to form a multi-channel self-balancing a.c. bridge which can provide different ranges on successive channels. The balancing system lends itself to the control of testing machines, especially for the production of a given time-pattern of load or strain. The use of other types of transducers is considered. Author

49. Simple force balance for drag measurements. G. A. HENWOOD, *J. Sci. Instrum.*, 1960, 37, 487-489. Chemical Engineering Division, A.E.R.E., Harwell, Berks. The drag force on a sphere was deduced from its horizontal deflection when supported as a simple pendulum in water flowing at between 0.2 to 0.8 cm./sec. Comparison with the results of another investigation have shown close agreement at Reynolds numbers about 25, but at about 100 this method yields drag forces some 13 per cent. high. A possible explanation of this discrepancy is suggested. W.G.C.

Section C

METALS AND OTHER SOLIDS

50. Impairment of strength of quartz glass through wetting by liquids. K. H. HILLER, *Nature, Lond.*, 1960, 188, 132-133. California Research Corp., P.O. Box 446, La Habra, California. The tensile strengths of quartz-glass rods immersed in water, oleylamine and *n*-hexa decane were measured using three-point bending. The rods were previously cleaned and dried before being marked with a standard scratch. The time which elapsed before fracture occurred was also noted when the rods were subjected to 95 per cent. of the mean rapid fracture load. It is suggested that the results may be explained by a mechanism involving a lowering of the interfacial free energy and not solely by a chemical solution process. W.G.C.

SECTION C

51. **Strength of silica glass.** I. NÁRAY-SZABÓ and J. LADIK, *Nature, Lond.*, 1960, **188**, 226-227. Central Research Institute for Chemistry, Hungarian Academy of Sciences, Hungária krt. 114, Budapest, 14. The value for the Si-O bond is calculated, based entirely on the assumption of Coulomb forces although the bond is partly covalent. This yields the strength of a silica fibre as 2.42×10^{11} dyne cm.⁻² This is compared with the maximum experimental value of 2.41×10^{11} dyne cm.⁻² W.G.C.

52. **Variation with temperature of Young's modulus of polycrystalline graphite.** I. B. MASON and R. H. KNIBBS, *Nature, Lond.*, 1960, **188**, 33-35. U.K. Atomic Energy Authority Research Group, A.E.R.E., Harwell, Berks. Measurements of Young's modulus of artificial graphites from 20° to 1000°C show that the variation with temperature is not always positive; a well-defined minimum being obtained at about 200°C. The data, illustrated graphically, were determined in a direction parallel to the extrusion axis, using a flexural vibration method. The results are discussed in relation to certain hypotheses. W.G.C.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

53. **On the applicability of the time-temperature superposition law in the dielectric relaxation phenomena.** Y. ISHIDA, M. YAMAMOTO and M. TAKAYANAGI, *J. Japan Soc. Test Matls.*, 1960, **9**, 233-235. Dept. of Applied Chemistry, Faculty of Engineering, Kyushu University, Fukuoka. A mutual inductance bridge has been used to extend the frequency range of dielectric relaxation measurement; the time-temperature superposition principle has been applied to both the high temperature and low temperature absorptions of polymers. For the high temperature case, the principle is obeyed above a reference temperature which is considerably higher than the glass transition temperature. For the low temperature, or β absorption, the principle is obeyed down to a temperature well below the glass transition temperature. Polymers studied include Nylon, PVC, Kel-F, and polyvinyl isobutyl ether. [Japanese, English summary] J.V.

54. **The relation of viscoelasticity of dielectricity and NMR in polymers.** A. MIYAKE, *J. Japan Soc. Test Matls.*, 1960, **9**, 264-267. Dept. of Physics, Faculty of Liberal Arts and Science Shizuoka University, Shizuoka. Relaxation time distributions obtained from studies of viscoelastic, dielectric and nuclear magnetic resonance spectra differ in form even though they are controlled by the same molecular motion. NMR activation energies are lower than those from the other two effects. Data for polymethyl methacrylate, polyisobutene and polytrifluoromono chloroethylene are analysed by a modified temperature reduction scheme give activation energies agreeing more closely for all three types of experiment. [Japanese, English summary] J.V.

55. Relationships between relaxation processes of polymers and temperature. S. SAITO and T. NAKAJIMA, *J. Japan Soc. Test Matls.*, 1960, 9, 253-287. Electrotechnical Lab., Agency of Industrial Science and Technology, Tokyo. Two, and sometimes three absorptions are detected by dielectric means in amorphous polymers. Particular molecular mechanisms are suggested for the different absorptions. J.V.

56. Viscoelasticity and structure change of high polymer solutions. M. NAKAGAKI, *J. Japan Soc. Test Matls.*, 1960, 9, 240-245. Faculty of the Science of Living, Osaka City Univ., Osaka. The Rouse theory of the viscoelastic properties of polymer solutions is extended to apply to a mixture of highly associated and single polymer molecules. By assuming that the ratio of these two components varies with velocity gradient, expressions are derived for the structural viscosity behaviour of such materials. [Japanese, English summary] J.V.

57. Rheological properties of concentrated polymer solutions. G. C. CINOGRAOV and V. N. MANIN, *Vysokomol. Soedinemiya*, 1960, 2, 329-336. [Russian, English summary]

58. Suggested method of plotting viscometry data for polymer solutions. C. MUSSA and V. TABLINO, *Polymer*, 1960, 1, 266-270.

59. Flow properties of linear polymers. H. J. KARAM, *Industrial and Engineering Chemistry*, 1959, 51, 851-853. The Dow Chemical Co., Midland, Mich. Some capillary rheometer data are reported and the effect of molecular parameters on rheological behaviour is discussed. The applications of rheology to practical problems are indicated. R.H.B.

60. Viscometric classification of polymer solutions. E. W. MERRILL, *Industrial and Engineering Chemistry*, 1959, 51, 568-870. Dept. of Chemical Engineering, M.I.T., Cambridge, Mass. Data obtained with two viscometers (low and high shear rate) are considered in respect to theories concerning the macromolecules as individual particles and in network aggregates. R.H.B.

61. Graphical evaluation of high polymer hysteresis. G. KEMMINTZ, *Faserforschung*, 1960, 11, 457-464. Glanzstoff-Courtaulds GmbH, Cologne, Germany. Tension-elongation data on nylon cords under oscillatory conditions are analysed in terms of a time-dependent phase difference between tension and elongation. (With discussion.) [German] A.S.L.

62. Hydrodynamic properties of polyelectrolytes. V. Viscosity studies on dilute solutions of 4-vinylpyridine-methacrylic acid copolymers. D. O. JORDAN and T. KURUCSEV, *Polymer*, 1960, 1, 185-192. University of Adelaide, South Australia. The concentration dependence of the reduced viscosity of aqueous polyampholyte solutions has a maximum at low concentrations. Previous explanations of this behaviour are discussed. The concentration dependence of the relative viscosity of the solutions studied is shown to be discontinuous.

SECTION D

63. Hydrodynamic properties of polyelectrolytes. VI. Viscosity studies on dilute solutions of poly-4-vinylpyridinium chloride. D. O. JORDAN and T. KURUCSEV, *Polymer*, 1960, **1**, 193-201. University of Adelaide, South Australia. The concentration dependence of the relative viscosity of partially neutralized poly-4-vinylpyridine is discontinuous both in aqueous solutions and in the presence of sodium chloride. The discontinuity is shown not to be an artifact of the technique of measurements. Possible explanations of the phenomenon are discussed. A tentative hypothesis involving aggregation of the poly-ions in solution is presented.

64. Hydrodynamic properties of polyelectrolytes. VII. Viscosity and streaming birefringence studies on dilute solutions of poly-4-vinylpyridinium chloride. D. O. JORDAN and T. KURUCSEC, *Polymer*, 1960, **1**, 202-211. University of Adelaide, South Australia. The streaming birefringence and orientation angles of aqueous poly-4-vinyl pyridinium chloride solutions may be interpreted in terms of the formation of poly-ion aggregates in solution. Aggregation mechanisms are discussed.

65. Investigation of tyre cords under oscillatory tensile stress. H. MEUMANN, *Faserforschung*, 1960, **11**, 444-456. Continental Gummiwerke A.G., Hanover, Germany. Tension-elongation hysteresis loops obtained from nylon and rayon tyre cords are exhibited on an oscilloscope using an apparatus due to Meskat *et al.* Effects of changing the amplitude, frequency, initial tension, and temperature are studied (with discussion). [German] A.S.L.

66. On the existence of near range order in isotactic polypropylenes. R. L. MILLER, *Polymer*, 1960, **1**, 135-143. A form of polypropylene, intermediate between amorphous and crystalline has been detected and studied by means which include dynamic mechanical measurements.

67. Viscoelastic meaning of force-temperature relationship at constant length in crystalline high polymers. M. TAKAYANAGI and M. YOSHINO, *J. Japan Soc. Test Matls.*, 1960, **9**, 297-300. Faculty of Engineering, Kyushu Univ., Fukuoka. Two relations are developed, one based on conventional time-temperature superposition and the other on a hypothetical stepwise cooling process. The two analyses are correlated on experimental results for polyethylene terephthalate. [Japanese, English summary] J.V.

68. Viscometric studies on polyisobutene solutions. D. H. PLESCH and P. P. RUTHERFORD, *Polymer*, 1960, **1**, 271-273.

69. Dielectric studies of copolymers of vinylidene chloride and vinyl chloride. S. NARITA and T. TABATA, *J. Japan Soc. Test Matls.*, 1960, **9**, 236-240. Tokyo Lab. of Kureha Kasei Co. Ltd., Tokyo. Six polymers were studied over a wide range of temperature and frequency. The proportion of vinyl chloride ranged from 20 to 95 per cent. Those with a small proportion of VC gave one dispersion, while a second higher frequency dispersion, the β dispersion, was observed if the proportion of VC was greater than 30 per cent. The glass transition temperature is lowered, and the activation energy decreases, with decreasing VC. [Japanese, English summary] J.V.

70. Rheological study of macromolecular compounds. Part 7. Effect of temperature on poly(vinyl) chloride liquid systems. Z. CSUROS, M. GARA, and GY. BERTALAM, *Periodica Polytech.*, 1960, 4, 9-32. [German]

71. Viscosity-molecular weight relationships for polymethyl acrylate. S. GUNDIAH, N. V. VISWANATHAN and S. L. KAPUR, *J. Sci. Industr. Res.*, 1960, 19B, 447-449. National Chemical Laboratory, Poona, India. From a study of the viscosity-molecular weight relationship of fractions of polymethyl acrylate, obtained by fractionating a 2 per cent. solution of the polymer in benzene using methanol as the precipitant, it has been concluded that though the solvent-solute interaction constants are altered in the polymer obtained by solution polymerisation in solvents of high chain transfer constants, the Mark-Houwink relation remains essentially unaltered.

Author

72. Non-Newtonian flow of concentrated solutions of high polymers. I. Polyvinyl alcohol systems. S. ONOGI, T. KOBAYASHI, Y. KOJIMA and Y. TANIGUCHI, *J. Japan Soc. Test Matls.*, 1960, 9, 245-249. Dept. of Textile Chemistry, Kyoto University, Kyoto. Apparent viscosity measurements, using a capillary viscometer with a variable pressure head have been made over a 2000 fold range of shear rates and a 35°C temperature range. The data superpose according to the method of reduced variables, and shift factors agree with those from dynamic data. [Japanese, English summary]

J.V.

73. Dynamic mechanical properties of rubber-styrene resin. A. NISHIOKA, K. MATSUMAE and T. TAMADA, *J. Japan Soc. Test Matls.*, 1960, 9, 268-272. Nippon Telegraph and Telephone Public Corporation, Electrical Communication Lab., Tokyo. Dynamic modulus and loss tangent measurements were made on rubber-styrene copolymers. A low temperature absorption at about -50°C is associated with the rubber part. The high temperature mechanical loss decreases on ageing, but the low temperature loss increases on ageing, due to chain scission in the rubber portion. It is concluded that there is little network structure between the two polymers. [Japanese, English summary]

J.V.

74. On the thixotropic phenomena observed in the vibration test of rubber vibration insulation. Y. SAWARAGI and M. FUKUDA, *J. Japan Soc. Test Matls.*, 1960, 9, 293-296. Faculty of Engineering, Kyoto Gakugei Univ., Kyoto. The vibration modulus falls linearly with log (number of strain cycles) until 4 to 9×10^4 cycles are reached, after which it remains constant. Empirical equations are developed to describe the fatigue process concerned. [Japanese, English summary]

J.V.

75. Influence of internal stresses on the adhesive properties of gelatine films. S. A. SHREINER and P. I. ZUBOV, *Kolloidnyi Zh.*, 1960, 22, 497. Leningrad Technol. Inst. for the Food Industry. Stress development during film formation on glass surfaces has been followed. There is a linear relation between film thickness and stress. A critical value of internal stress is proposed for evaluating adhesive properties of films and surface strength of substrates. [Russian, English abstract]

G.W.S.B.

SECTION D

76. Investigations on the structural-mechanical properties of gelatine. S. M. Levi, *Kolloidnyi Zh.*, 1960, **22**, 599. Research Inst. for Cinephotography, Moscow. Depending upon the concentration and temperature, gelatine solutions may possess the properties of Newtonian liquids or of a visco-elastic body. The formation of a structure on cooling gelatine solutions requires a certain time during which the solutions possess only true viscosity. From the moment of gel structure formation continuous thixotropic growth of viscosity and of the yield-value is observed in the gelatine solution. As a result the solution loses its fluidity and a gel is formed. This transition is accompanied by important structural changes manifested in a jumpwise growth of the yield-value and elasticity modulus. [Russian. English abstract] Author

77. Behaviour of paper during tensile straining. A. E. RANGER and L. F. HOPKINS, *Nature, Lond.*, 1960, **187**, 1097-1098. Bowater Research and Development Co. Ltd., Research Division, Northfleet, Kent. The view is advanced that in the tensile testing of paper the final fracture is predominantly governed by failure of the individual fibres, and that the inter-fibre bonds are mainly broken during the straining process. A bond failure mechanism is proposed in order to account for the phenomenon of strain lines, which occur when a strip of paper is strained. The variation in the strain-like angle to the fibre orientation in a paper has been predicted, and its agreement with observed data is considered not unsatisfactory. W.G.C.

78. The torsional properties of single wool fibres. Part 1. Torque-twist relationships and torsional relaxation in wet and dry fibres. T. W. MITCHELL and M. FEUGHELMAN, *Text. Res. J.*, 1960, **30**, 662-667. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Ryde, N.S.W., Australia. An apparatus is described for the direct measurement of torque-twist relationships for single wool fibres. Calculation of the rigidity of a dry fibre (0 per cent. R.H.) agrees with results obtained by Speakman, who used a torsion pendulum technique. However this latter technique is shown to give an underestimation of the rigidity of the fibre at 100 per cent. R.H. This discrepancy is explained as being due to the hyperbolic relationship between the torque and twist of a single fibre. Measurements were also carried out on the torque relaxation of a single fibre, both wet and dry at fixed values of twist. All the results obtained are consistent with a molecular model in which the matrix consists of a cross linked polymer held together by a network of hydrogen bonds. Author

79. The degree of polymerisation and its distribution in cellulose rayons. Part X. A quantitative theory of the tenacity and breaking extension of regenerated cellulose monofilaments. R. J. E. CUMBERBIRCH and C. MACK, *J. Text. Inst.*, 1960, **51**, T458. The British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester, 20. The paper describes a simplified model structure for cellulose regenerated from secondary cellulose acetate. From this model structure theoretical relations of breaking strength and breaking extension to degree of polymerisation (D.P.) are derived and are shown to agree well with experimental results. The fitting of these relations enables estimates to be

made of crystallite size and of percentage crystallinity. These estimates are in good agreement with the experimentally obtained values. It is also shown that a negligible fall in D.P. can be expected to occur on the mechanical rupture of the filaments.

Author

80. Optical polarization studies of processes of plastic deformation using solutions and gels of ethyl cellulose. D. N. OSOKINA, M. V. GZOVSKII, G. V. VINOGRADOV and V. P. PAVLOV, *Kolloidnyi Zh.*, 1960, **22**, 434. Shmit Institute of Earth Physics, Moscow. With the objective of obtaining a photoplastic material of viscosity 10^2 – 10^3 poise a study was made of 10–35 per cent. ethylcellulose solutions and gels in benzyl alcohol and in benzyl alcohol-dibutyl phthalate mixtures. The use of a novel apparatus, the photoplastoviscometer, allowed simultaneous plots to be obtained of the dependence of the double refraction Δn and viscosity upon the yield-value τ and the rate of deformation D . Solutions of ethylcellulose in benzyl alcohol are highly viscous liquids, approaching the Newtonian type with a practically linear Δn - τ relation. The addition of dibutyl phthalate transforms them to plastic structured bodies with non-linear dependence of Δn upon τ . The optical activity coefficient $B\tau$ is independent of the ethylcellulose concentration and has a value of the order of $6 \cdot 10^4$ brewsters, which is considerably greater than that of all photoelastic and photoplastic materials known heretofore. The applicability of ethylcellulose solutions as photoplastic material has been confirmed on a model of the deformable part of the crust of the earth. The investigation has shown the possibility of studying stress-strain relations in soft plastic bodies with the aid of the optical polarization method, which is of considerable interest in the solution of various rheological problems. [Russian. English abstract]

Author

81. The viscoelastic properties of the regenerated cellulose fibres in water. K. SHIRAKASHI, K. ISHIKAWA, M. SEGAWA and G. K. JOARDER, *J. Japan Soc. Test Matls.*, 1960, **9**, 307–312. Dept. of Textiles, Tokyo, Institute of Technology, Ōokayama, Meguro-Ku, Tokyo. [Japanese, English summary]

J.V.

82. The mechanical behaviour of wool fibre in water. K. SHIRAKASHI and N. OGUCHI, *J. Japan Soc. Test Matls.*, 1960, **9**, 301–306. Dept. of Textiles Tokyo Institute of Technology, Ōokayama, Meguro-Ku, Tokyo. The shape of the fatigue curves for wool depends on the relation between the rate of creation and fracture of secondary bonds. [Japanese, English summary]

J.V.

83. Viscometric studies of cellulose in jute fibre during mechanical processing. H. CHATTERJEE and A. K. MAZUMDAR, *J. Sci. Industr. Res.*, 1960, **19B**, 369–370. Technological Research Labs., Indian Central Jute Committee, Calcutta. The effects of mechanical processing of jute and mesta fibres into yarn and reduction of fibre size in a laboratory mill have been investigated to find out whether these treatments cause any chemical degradation of cellulose.

Author

SECTION D

84. Diffusion controlled mechanical properties of uncoated Cellophanes. H. YAMAMURA and Y. TADOKERO, *J. Japan Soc. Test Mats.*, 1960, **9**, 273-277. Chemical Lab., Faculty of Science, Hiroshima Univ., Hiroshima. The creep equation for a Voigt model is extended to take into account the effect of a non-Fickian diffusion process which affects the flow parameters. [Japanese, English summary] J.V.

85. Viscosity-molecular weight relation for high molecular weight poly-(dimethylsiloxane). S. FURUYA, *J. Japan Soc. Test Mats.*, 1960, **9**, 288-292. Nippon Telegraph and Telephone Public Corporation, Electrical Communication Lab., 1551, Kichijaji, Musashino-shi, Tokyo.

86. Nuclear magnetic resonance study of molecular motion in polydimethylsiloxane. C. M. HUGGINS, L. E. ST. PIERRE and A. M. BUECHE, *J. Phys. Chem.*, 1960, **64**, 1304. General Electric Research Laboratory, Schenectady, New York. The proton magnetic resonance (n.m.r.) spectra of polydimethylsiloxane were determined over the temperature range 77-300°K. The spectra are characterized by an unusually narrow resonance line at room temperature indicating a low microscopic viscosity in the polymer. At 77°K the line width broadened to 49 Gauss peak-to-peak, compatible with a rigid lattice and free rotation of the methyl groups. The line narrowing data indicate a chain rotational process with an activation energy of 8 K.Cal./Mole. The combination of the n.m.r. data with X-ray melting point and dielectric loss data confirms the presence of a "second-order" transition in the crystalline polymer considerably below the crystal melting point. This transition is thought to be primarily the onset of a chain rotation but evidence also is presented for chain translational motion in the crystalline state. Author

87. Rheological study of macromolecules. Part 6. Determination of secondary reaction points by Hoppler consistometers. Z. CSUROS, M. GARA and G. BERTALAN, *Magyar Kem. Folyoirat*, 1960, **66**, 174-178. [Hungarian, German summary]

Section E

PASTES AND SUSPENSIONS

88. Review of research studies showing need for a viscosity test below 1 sec⁻¹. E. L. ARMSTRONG, *N.L.G.I. Spokesman*, 1960, **25**, 173-176. Socony Mobil Oil Co. Inc. The author reviews a large volume of work appertaining to the measurement of the flow characteristics of lubricating greases. He concludes that in order to predict the behaviour of greases in practice it is often necessary to make measurements at rates of shear as low as 0.1 seconds⁻¹. The author has confined himself to lubricating greases but similar conclusions might be drawn for other non-Newtonian materials. A.D.B.

89. Non-Newtonian flow behaviour of vinyl resin plastisols. H. L. GUNNERSON and J. P. GALLAGHER, *Industrial and Engineering Chemistry*, 1959, **51**, 854-855. The Goodyear Tire & Rubber Co., Akron, Ohio.

90. Fall of liquid drops through pseudoplastic liquids. M. V. MHATRE and R. C. KINTNER, *Industrial and Engineering Chemistry*, 1959, 51, 865-867. Illinois Institute of Technology, Chicago, Ill.

91. Thixotropy. Part 2. Thixotropic gel structure of bentonite. T. Watanabe, *Bull. Chem. Soc. Japan*, 1960, 33, 523-527.

92. The hydrodynamic effect between approaching surfaces—its influence on surface profiles during plastic deformation. L. H. BUTLER, *J. Inst. Petrol.*, 1960, 46, 289-293. University College, Cardiff. Compression tests have been carried out on 1-inch diameter \times 1-inch long cylindrical mild steel specimens using flat contact dies. The die-to-metal interfaces were both unlubricated and lubricated with high viscosity fluids, and the moving die approach speed was controlled at 1 inch/min and 9 inches/min. The specimen contact face profiles were measured before and after compression. The final profiles and surface appearances indicate that under moderate approach conditions and using an appropriate lubricant, it is possible to deform the material well into the plastic range via a continuous lubricant film stimulated initially by the hydrodynamic mechanism. The film is maintained by a mechanical sealing effect after initial metal contact occurs. The consequences of the presence of such films is discussed with reference to the magnitude and constancy of values of coefficient of friction during forming operations. Author

93. Grease worker results and their significance in anti-friction bearing lubrication. E. SILLETT, *Lubric. Engng.*, 1960, 16, 477-480. Canadian Westinghouse Co. Ltd., Hamilton, Ontario. Changes of consistency in laboratory working tests are related to the behaviour of greases in bearings. If the bearing is vibrating or over-filled with grease, a grease that softens on working will tend to leak out of the bearing, whereas in a properly mounted and packed bearing such a grease will not leak. J.F.H.

94. Relaxation phenomena in lubrication. E. O. FORSTER, *Lubric. Engng.*, 1960, 16, 523-528. Esso Research and Engineering Co., Linden, New Jersey. Elastic effects have been reported for low viscosity lubricating oils at loading times less than 10^{-12} to 10^{-9} seconds; for polymer-containing oils (multigrade) at 10^{-6} to 10^{-4} seconds; for greases at 10^{-1} seconds or higher. Loading times in typical bearings range from about 10^{-2} to 10^{-6} seconds, going from piston rings to high-speed ball bearings. Thus, many lubricants will behave elastically rather than viscously in service. An elastic lubricant film will withstand heavier loads than a viscous film. It is pointed out that the simultaneous effects on visco-elastic properties of pressure and temperature must also be taken into account. J.F.H.

95. Flow properties of sericite suspension. H. NODA and B. TAMAMUSHI, *J. Japan Soc. Test Matls.*, 1960, 9, 341-344. University of Tokyo (Tokyo Women's Christian College, Tokyo). [Japanese, English summary] J.V.

96. Structure formation in Askangel suspensions and their derivatives. O. M. MDIVNISHVILI, G. V. VINOGRADOV and S. A. GOL'DIN, *Kolloidnyi Zh.*, 1960, 22, 606. Caucasian Inst. of Mineral Raw-materials, Tbilisi.

SECTION E

Optical- and electron-microscopy of Na, Ca and Al-bentonites shows structures claimed to be responsible for rheological behaviour. [Russian. English abstract] G.W.S.B.

97. A study of humus sols from peat. I. Structural-mechanical properties and their changes under the influence of additives. M. P. VOLAROVICH, I. I. LISHTVAN and N. V. CHURAEV, *Kolloidnyi Zh.*, 1960, 22, 546. Kalinin Peat Institute, Moscow. Using a capillary viscometer, the greatest effects are found using the highest concentrations of dispersed phase and small additions of electrolytes. [Russian. English abstract] G.W.S.B.

98. Factors affecting the flow properties of oil-in-water emulsions. M. MOMOTANI and S. MATSUMOTO, *J. Japan Soc. Test. Matls.*, 1960, 9, 325-330. Research Lab., Momotani-Juntanken, Ltd., Minatoku, Osaka. The effect of hydration layers and other surface phenomena on non-Newtonian flow is discussed. [Japanese, English summary] J.V.

99. The subsidence rates of suspensions of lithium stearate in *n*-heptane with *n*-alcohols as additives. M. J. VOLD and D. V. RATHNAMMA, *J. Phys. Chem.*, 1960, 64, 1619. Department of Physical and Inorganic Chemistry, The Indian Institute of Science, Bangalore, India. Suspensions of lithium stearate in *n*-heptane are highly unstable, undergoing gelation even at concentrations as low as 1 g/l. The rate of subsidence of these weakly gelled suspensions is decreased at first by the addition of *n*-alcohols, but passes through a minimum in some cases. The minimum subsidence rate occurs while the adsorption of the alcohols is still below its saturation value. One possible explanation of the effect is that the solvent layer between particles at the junction points in the gel becomes simultaneously more polar, tending toward an increased gel strength, and also thicker, tending toward a decreased gel strength. Author

100. Changes in the damping decrement and oscillation period of a torsion pendulum in two-sided soap films during the thinning process, until rupture. A. A. TRAPEZNIKOV and K. V. ZOTOVA, *Kolloidnyi Zh.*, 1960, 22, 482. Lab. of Oleocolloids and Monolayers, Inst. of Physical Chem., Acad. Sci. U.S.S.R., Moscow. The changes in mechanical properties of two-sided films in the process of the thinning is of considerable interest in connection with problems of their stability. A study has been made of the changes in the damping decrement λ and the oscillation period T of a torsion pendulum in a two-sided film of a foaming agent during thinning of the film up to its rupture (60-70 hours). The changes in λ are studied from the standpoint of the Marangoni and Gibbs effect, i.e. in terms of pseudo-viscosity and pseudo-elasticity. [Russian. English abstract] Author

101. Critical conditions for brittle fracture of asphalts in extension. R. GOTOH and H. AIDA, *J. Japan Soc. Test. Matls.*, 1960, 9, 331-335. The Institute for Chem. Research, Kyoto University, Kyoto. A critical strain rate is reached when the viscous resistance exceeds the local cohesive forces. The effect of very fine fillers is investigated. [Japanese. English summary] J.V.

LIQUIDS

Section F

LIQUIDS

102. Measurement of viscosity of liquids by Poiseuille's method—a correction. N. SUBRAMANIAN and P. RAJAGOPALA RAO, *J. Sci. Industr. Res.*, 1960, **19B**, 368–369. Laxminarayan Institute of Technology, Nagpur Univ., Nagpur, India. A new correction factor, which takes into account the average excess pressure at the exit of a tube during the time of drop formation, has been suggested to be introduced in the Poiseuille equation for pressure in terms of the rate of flow. Author

103. Flow measurements in closed conduits. J. H. PRESTON, *Nature, Lond.*, 1960, **188**, 786–787. A brief report of a symposium held at the National Engineering Laboratory, East Kilbride, Glasgow, during September 27–30.

104. Flow of entrapped bubbles through a capillary. R. N. MARCHESSAULT and S. G. MASON, *Industrial and Engineering Chemistry*, 1960, **52**, 79–84. Pulp and Paper Research Institute of Canada, Montreal, Canada. Direct methods were used to investigate the properties of the liquid film separating the moving bubble and the wall. An approximate theory assuming that the distorted bubble behaves as a solid cylindrical plug accounted for most of the experimental observations. R.H.B.

105. Rheological properties of fermentation broths. F. H. DEINDOERFER and J. M. WEST, *Industrial and Engineering Chemistry*, 1960, **52**, 59. Squib Institute for Medical Research, New Brunswick, N.J.

106. The wake of a moving drop. R. H. MAGARVEY and R. L. BISHOP, *Nature, Lond.*, 1960, **188**, 735–736. Dept. of Physics, Acadia Univ., Wolfville, Nova Scotia, Canada. The wakes of single drops of various organic liquids, moving through water at terminal velocity, have been observed and recorded photographically. The wake pattern was rendered visible as a water-soluble dye was scrubbed from the moving drop. With carbon tetrachloride, observations have been made with drop sizes approaching 0.32 cm. and Reynolds numbers up to about 900. Provided the natural oscillations of the drops are not large the wake is symmetrical and is characterized by two rows of vortex rings. W.G.C.

107. Studies on Indian plant gums : effect of pH on the viscosity of acacia catechuic acid. V. K. KULSHRESTHA and S. W. MUKHERJEE, *J. Sci. Industr. Res.*, 1960, **19B**, 309–311. Dept. of Physical Chemistry, Jadavpur Univ., Calcutta. As the pH is increased the viscosity of acacia catechuic acid rises rapidly and becomes maximum at a pH of C. 6.5 ; after this, it falls slowly followed by a rapid decrease with rise in pH, reaching nearly a constant value at a pH of 12. These results have been explained on the basis that there is folding and unfolding of the molecular chains in the solution and that it behaves as a " polyelectrolyte ". Author

SECTION G

Section G

GENERAL

108. The sixtieth birthday of Prof. M. P. Volarovich. (An editorial appreciation.) *Kolloidnyi Zh.*, 1960, 22, 513. [Russian]

109. Report : On the work of the rheology section on the All-Union Congress on Mechanics. N. V. LOZOVSKAYA, *Kolloidnyi Zh.*, 1960, 22, 643. [Russian]

110. Frictional resistance of a radially-loaded journal bearing with grease lubrication. R. K. CHAKRABARTI and R. J. HARKER, *Lubric. Engng.*, 1960, 16, 274-280. University of Wisconsin, Madison, Wis. Bearing tests were carried out on lithium soap greases of different soap contents and containing a high and a low viscosity oil. With the bearing operated concentrically (no load) the constants of the Bingham equation were obtained for each grease. Results for the loaded bearing were treated by dimensional analysis using five dimensionless groups. It was found that the torque could be expressed as a simple sum of four terms ; in speed, load, speed times load and a constant. The significance of this relationship is discussed. J.F.H.

111. Fundamental processes in lubricating metal surfaces at 100° to 1700° F. E. N. KLEMGARD, *Lubric. Engng.*, 1960, 16, 468-476. Washington State University, Pullman, Wash.

112. A low temperature study of the relationship between engine cranking speed and lubricant viscosity. THEODORE W. SELBY, *ASLE Transactions*, 2, 208-216. General Motors Corporation, Warren, Michigan. The viscosity of motor oils at low temperatures strongly affects the cranking speed of the motor. In a previous paper the author has shown that the viscosity characteristics of motor oils at low temperatures may be unusual, especially when they contain Viscosity Index Improvers. In this paper the author has analysed the results of 250 cranking tests on two different V-8 engines conducted at temperatures from +3 to -35°F, using three fluids, two of which contained Viscosity Index Improvers. The data seem to indicate an exponential relationship between the cranking torque M , and the cranking speed, N , and viscosity, μ , such that $M = c(\mu N)^b$ in which b and c are constants and $b \approx 0.5$. Further results of this study strongly indicate that the correlation is significantly better between cranking speed and viscosities measured at shear rates of approximately 2000 sec⁻¹ than the correlation between these cranking speeds and viscosities determined by the ASTM extrapolation technique (Walther equation), or by a recent empirical modification of this technique.

Author

113. Fluid systems. D. W. DODGE, *Industrial and Engineering Chemistry*, 1959, 51, 839-840. E. I. du Pont de Nemours & Co., Inc., Buffalo, N.J. A review of the definitions of non-Newtonian materials.

GENERAL

114. Stress effects on thermoremanent magnetisation. J. M. HALL and R. N. NEALE, *Nature, Lond.*, 1960, **188**, 805-806, 843. Applied Geophysics Dept., Imperial College, London, S.W.7. It has been shown that the effect of stress on a rock acquiring a thermoremanent moment is not completely reversible for all rocks. Details of the rock used and of the experimental conditions are given. These results indicate that grain size and anisotropy may be contributory factors to this difference between rocks. W.G.C.

115. Albert the bookworm. E. G. ELLIS, *Scientific Lubrication*, 1960, **12**, No. 12, 29-31. A Christmas story describing how an oil salesman overcame the difficulties of describing to his customers the properties of a thixotropic lubricant. J.F.H.

Summaries of papers to be read at a meeting organised by the Society on "Theoretical Rheology", to be held at the University of Reading on April 20-21, 1961.

Non-Newtonian Flow and Die-Design

By J. R. A. PEARSON (University of Cambridge)

One of the present difficulties in the design of dies for the extrusion of thermoplastics is caused by the appearance of weak lines in the extrudate: for "spider" dies these are associated with the polymer flowing past the spider legs; for "cross-head" dies these are associated with the region in which polymer flowing around either side of the central spigot reunites.

An attempt is made to explain the persistence of the flow defects caused by obstructions in a flowing polymer stream in terms of certain simplified non-Newtonian fluid models, in particular by comparing the results for these models with their Newtonian counterparts.

Flow of non-Newtonian Liquids in Pipes

By J. R. JONES (University College of Swansea)

OLDROYD [1] has studied theoretically the flow of certain idealized incompressible visco-elastic liquids characterized by eight independent physical constants. Referred to an orthogonal frame of reference Ox_i , the liquids are those whose invariant differential equations of state for general motion, relating the stress tensor p_{ik} and the rate-of-strain tensor e_{ik} , take the form

$$\begin{aligned} p_{ik} &= p'_{ik} - p'' \delta_{ik} \\ p'_{ik} &+ \lambda_1 \frac{\mathcal{D} p'_{ik}}{\mathcal{D} t} + \mu_0 p'_{ij} e_{ik} - \mu_1 (p'_{ij} e_{jk} + p'_{jk} e_{ij}) + v_1 p'_{j\ell} e_{j\ell} \delta_{ik} \\ &= 2\eta_0 (e_{ik} + \lambda_2 \frac{\mathcal{D} e_{ik}}{\mathcal{D} t} - 2\mu_2 e_{ij} e_{jk} + v_2 e_{j\ell} e_{j\ell} \delta_{ik}), \end{aligned}$$

where $\mu_0, \lambda_1, \lambda_2, \mu_1, \mu_2, v_1$, and v_2 , are scalar constants and p'' is an isotropic pressure which varies with position x_i and time t in a way determined by the equations of motion. The material derivative $\mathcal{D} b_{ik} \dots r / \mathcal{D} t$ of any Cartesian tensor $b_{ik} \dots r(x_i, t)$ is defined by

$$\begin{aligned} \frac{\mathcal{D} b_{ik} \dots r}{\mathcal{D} t} &\equiv \frac{b_{ik} \dots r}{\partial t} + v_j \frac{\partial b_{ik} \dots r}{\partial x_j} + \omega_{ij} b_{ij} \dots r + \omega_{kj} b_{ij} \dots r \\ &+ \dots + \omega_{rj} b_{ik} \dots j \dots \end{aligned}$$

Here v_i is the velocity vector and ω_{ik} the vorticity tensor. OLDROYD has shown that certain liquids of this class exhibit (in the modes of flow

considered) rheological behaviour which is consistent with the observed behaviour of some real elastico-viscous liquids. It is therefore clearly worthwhile to take the above equations as a realistic rheological model representing some elastico-viscous liquids.

A particular mode of flow discussed by OLDROYD was that of steady rectilinear flow in a straight pipe of circular section maintained by a uniform axial pressure gradient alone. In the present paper the essential features of the stress distribution are shown to remain unchanged when there is a central core present, concentric with the inner wall of the pipe and moving with a constant prescribed velocity parallel to its axis. In the case of steady axially symmetrical flow, using cylindrical polar co-ordinates r, θ, z such that $r = 0$ is the common axis, the only non-vanishing components of stress $p_{rr}, p_{\theta\theta}, p_{zz}$ and p_{rz} are all functions of r only. For this symmetrical flow the core does not experience a resultant transverse force. This will no longer be true for other boundaries in particular for an eccentric circular core and in this connection an interesting problem is that of determining the stability of the core if this is free to move laterally parallel to itself. To solve it we calculate the stresses at the walls needed to maintain steady flow in straight lines in a pipe with an eccentric core of circular section, and we deduce the force on the core when displaced from the central position. This problem has practical importance since it appears that in experiments of this type great difficulty is found in centralising the cores.

In the second part of the paper an analysis is made of flow, in a curved pipe, of the inelastic liquids defined by the above equations with $\eta_0 > 0, \mu_2 \neq 0, \lambda_1 = \lambda_2 = \mu_0 = \mu_1 = v_1 = v_2 = 0$; the pipe being of circular cross-section and coiled in a circle. It is found necessary to approximate by supposing that the curvature of the pipe is small, more precisely that the radius of the circle in which the pipe is coiled is large in comparison with the radius of the cross-section. The streamlines in the plane of symmetry and the projection of the streamlines on a normal section are compared with those of a Newtonian liquid.

References

- 1 OLDROYD, J. G. *Proc. Roy. Soc.*, 1958, A, **245**, 278.

Flow Phenomena during Powder Compaction

By F. C. ROESLER (I.C.I. Billingham Division)

The transformation of a powder into a compact, coherent solid can, in some cases, be carried out as a continuous process by feeding the powder to a system of counter-rotating rollers. The dynamics of this process can be treated by taking account of the geometry and of the kinematic boundary conditions of the roller gap and also of the flow properties of the material. The latter change as the density of the material and its state of aggregation change. The problem is therefore relatively complex, and at first sight not readily solvable. But it turns out that the classical ideas of COULOMB on the mechanics of granular materials, the hypothesis of MOHR on the existence of a certain surface stress-space which characterises failure, and modern plasticity theory, can be combined to give a simple model of the process. The mathematical description of the field of pressure and flow between the rollers can then

be condensed into one differential equation. By studying suitably chosen families of solutions of this equation, the rolling compaction process can be understood quantitatively.

Stress waves in anisotropic media

By M. J. P. MUSGRAVE (National Physical Laboratory)

The dynamics of elastic waves in anisotropic media will be sketched and some quantitative results for media of hexagonal symmetry will be presented and given physical interpretation.

A justification for the use of the elastic theory in dealing with materials of small absorption will be offered.

The relevance of the theory to the technique known as sono-elasticity will be indicated.

Finite strain viscoelasticity

By J. G. OLDROYD (University College of Swansea)

It is possible to construct simple sets of rheological equations of state that represent visco-elastic behaviour in solids in which large recoverable strains can occur. This is done in a way that is somewhat analogous to the construction of spring-dashpot models—or, equivalently, sets of linear differential equations relating stresses and infinitesimal strains—to represent viscoelasticity in hard elastic solids. A number of independent deformation mechanisms in the material element, each representing some kind of rubber-like elastic response to stress together with delay in the response due to internal friction, can be combined in such a way that the idealized behaviour of the material is consistent with the laws of thermodynamics. (The analogue of this for hard solids is the generalised Voigt solid.)

In the simplest case that can be envisaged, the principal directions of strain in each of the independent deformation mechanisms in a material element are taken to be the principal directions of stress on the element, when these do not change with the time. If the principal extension ratios associated with the separate deformation mechanisms are denoted by (a_1, a_2, a_3) , $(\beta_1, \beta_2, \beta_3)$, $(\gamma_1, \gamma_2, \gamma_3)$, etc., the whole deformation has extension ratios $\lambda_1 = a_1 \beta_1 \gamma_1 \dots$, $\lambda_2 = a_2 \beta_2 \gamma_2 \dots$, $\lambda_3 = a_3 \beta_3 \gamma_3 \dots$. The partial deformation parameters (the α 's, β 's, γ 's, etc.) occur in the equations of state and cannot usually be eliminated from them; the equations of state define the α 's, β 's, γ 's implicitly in terms of the principal stresses, all regarded as functions of the time, and hence the whole deformation history (the λ 's, as functions of the time) is defined in terms of the stress history.

The extension of this sort of idealized model to essentially fluid materials, to illustrate the possibility of flowing liquids showing rubber-like elasticity and large recoverable strains, provides an example of a set of equations of state that is known to be consistent with thermodynamical principles, representing fairly complicated elastico-viscous behaviour.

Creep and stress relaxation in crystalline solids at low temperatures

By P. FELTHAM (The University, Leeds)

OL.
4
961

The logarithmic law of stress relaxation under constant strain, frequently observed in solids at low temperatures, was studied in the range 77 to 358° K in copper, iron containing 0.1 per cent. by weight of carbon, and in brasses with zinc-contents of 10 to 35 per cent. The relaxation strength $s_r(T)$, defined by $d\sigma/d \log_{10} t$, where σ is the tensile stress at a time t after the initiation of the relaxation, increased sharply with temperature, in iron, for example, from 197 kg/cm² at 358° K to 313 kg/cm² at 77° K. This behaviour is explained, and the logarithmic form of stress relaxation derived, by means of a theoretical model in which small local shears take place in constant stress gradients, the rate of shearing being controlled by a strongly stress dependent activation energy. Logarithmic stress relaxation, and logarithmic creep under an invariant stress are shown to be conjugate provided the coefficient of work-hardening $\chi = d\sigma/d\varepsilon$ is constant; the relation $s_r(T)/s_c(T) = -\chi$, where $s_c(T) = d\varepsilon/d \log_{10} t$ denotes the "creep strength" and ε the instantaneous tensile strain, was experimentally confirmed.

The significance of the strain ellipsoid in the case of large plastic strain

By T. LL. RICHARDS (College of Advanced Technology, Birmingham)

Any small strain at a point in a solid can be represented by the change in shape of a small spherical element of the undeformed solid. The deformed shape is an ellipsoid, the principal axes of which represent an unique set of orthogonal strains defining the particular strain. Further, if the two shapes are superimposed with common centres, their surfaces intersect along the locus of the extremities of common radii which are unchanged in length. These radii, therefore, are directions in which it is possible to perform the strain by pure shear. Plastic deformation of solid materials would thus be expected to occur by shear in such directions or in perpendicular directions.

For large strains of unspecified magnitude the strain ellipsoid is of little value, but it is still useful to define a *mode of deformation* in terms of the relative magnitudes of the principal components involved in an incremental strain. Thus, in simple plastic extension, for example (i.e. involving no change in volume) a small extension $e \rightarrow \varepsilon_0$ in direction OX is accompanied by contractions $-e/2$ along OY and OZ , and the radii which are unextended define a cone of semi-angle θ about OX where $\tan \theta = \sqrt{2}$, i.e. $\theta = 54.44^\circ$. Similar definitions can be established for deformation by compression or by rolling, etc.

Various implications and applications of the strain ellipsoid will be mentioned, which include a statement of the principle of orthogonal shears; a new definition of the plasticity of solids to cover the full range from brittle to ideally plastic solid; the derivation of the shear systems in cubic metal crystals and deformation textures.

VOL.
4
1961

Section A

THEORETICAL

116. A thermodynamic approach to rheology. H. H. HULL, *Trans. Soc. Rheol.*, 1960, 4, 367-368. R. R. Donnelley Co., Chicago, Illinois. Work done in deforming a body is dissipated partly as heat, partly as potential energy. The latter could be called rheological free energy. A thermodynamic system based on this is developed, using phase rule analogies.

117. A re-interpretation of the Rouse-Bueche theory of viscoelastic behaviour. R. S. MARVIN, *Trans. Soc. Rheol.*, 1960, 4, 365. National Bureau of Standards, Washington, D.C. The Rouse-Bueche theories considered the response of a single polymer molecule to macroscopic forces acting on a bulk sample. From this, Ferry and Bueche derived expressions for the response of a bulk sample with a given molecular weight distribution. The author presents an alternative view of the derivation which suggests that the theories (or their equivalent Voigt or Maxwell model representations) should refer to the bulk response of the sample, rather than that of a single chain.

118. Some properties and problems of the liquid state. N. E. CUSACK and J. E. ENDERBY, *Research*, 1959, 12, 475-481. Birkbeck College, University of London. Three methods of studying liquid structure, by statistical mechanical theories assuming an interaction function, by direct geometrical methods, and by using "Cell theories" are described.

119. Viscoelasticity and liquid structure. P. MASON, *Research*, 1960, 13, 234-239. British Rubber Producers Research Association, Welwyn Garden City. Theories of time-temperature equivalence of rheological properties are reviewed, and their relation to free volume concepts of liquid structure is discussed.

120. The behaviour of particles in laminar shear. S. G. MASON, *Trans. Soc. Rheol.*, 1960, 4, 366. Pulp and Paper Research Institute of Canada, Montreal. The general behaviour of solid spheres, fluid drops, rigid and flexible rods and fibres in a velocity gradient is described.

121. Unsteadiness of some flows with free surfaces. M. I. GUREVICH, *Dokl. Akad. Nauk*, 1959, 124, 998.

122. Dynamics of frictional compressible fluids—application to plasticodynamics. C. TORRE, *Trans. Soc. Rheol.*, 1960, 4, 367. M. W. Kellogg Co., Jersey City, N.J. The dynamics of frictional compressible fluids is formulated by 11 equations—3 of motion in a continuum, a "specifying" equation and 6 stress-rate of strain equations. The 11 unknown are 6 stresses, 3 velocities, pressure and density. Methods of solving the quasi-linear partial differential equations are indicated.

123. Relations defining plastic flow on Tresca's condition of plasticity and its generalization. D. D. IVLEV, *Dokl. Akad. Nauk*, 1959, 124, 546.

124. A boundary value problem for linearized equations of the viscous fluid dynamics. S. S. LITVINKOV, *Dokl. Akad. Nauk*, 1959, 125, 998.

SECTION A

125. The method of singularities as applied to designs of liquid flow in radially axial turbines. S. V. VALLANDER, *Dokl. Akad. Nauk*, 1958, 123, 413.

126. Creep of ice in frozen skeleton grounds under compound stress. A. U. BIRKGAN and A. S. VOL'MIR, *Dokl. Akad. Nauk*, 1960, 135, 1079.

127. The solubility of the two-dimensional problem in the theory of small elastico-plastic deformations. I. U. P. KRASOVSKII, *Dokl. Akad. Nauk*, 1959, 126, 961.

128. Hydraulic and kinematic pressure characteristics for unhomogeneous dispersed systems in pipes. A. E. SMOLDYREV, *Dokl. Akad. Nauk*, 1959, 129, 993.

129. Stress relaxation and creep as viscous flow processes. N. S. FASTOV, *Dokl. Akad. Nauk*, 1960, 130, 64.

130. Unhomogeneity of plastic deformation under tensile stress. B. M. STRUNIN, *Dokl. Akad. Nauk*, 1960, 130, 310.

131. On the thermodynamics of the irreversible processes involved in plastic deformation. N. S. FASTOV, *Dokl. Akad. Nauk*, 1960, 130, 541.

132. Converging wave in plastic medium. E. I. ANDRIANKIN, *Dokl. Akad. Nauk*, 1960, 131, 769.

133. Equilibrium and motion of a sphere in a viscoplastic fluid. U. Ts. ANDRES, *Dokl. Akad. Nauk*, 1960, 133, 777.

134. Initiation and development of cracks in crystals during the process of deformation. L. A. KOCHANOVA, *et al.*, *Dokl. Akad. Nauk*, 1960, 133, 71.

135. Some features of the brittle fracture of metal crystals. E. D. SHCHUKIN, *et al.*, *Dokl. Akad. Nauk*, 1960, 133, 1064.

136. On the relation between the velocities of modern vertical motion of the earth crust, geophysical fields, and geostructural elements. A. T. DONABEDOV, V. A. SIDOROV, K. V. TIMAREV and L. N. TORKHOVSKAIA, *Dokl. Akad. Nauk*, 1960, 132, 810.

137. An investigation of the spontaneous shrinking of polymers with a developed space structure when they are being ruptured. V. E. GUL' *et al.*, *Dokl. Akad. Nauk*, 1960, 133, 1364.

138. Gas flow from a vessel with plane walls forming a small angle. A. ARYNOV, *Dokl. Akad. Nauk*, 1958, 123, 43.

139. Potential steady relativistic gas flows. F. I. FRANKL, *Dokl. Akad. Nauk*, 1958, 123, 47.

THEORETICAL

140. On the boundary problem of generalized hydrodynamics. I. I. OLKHOVSKY, *Dokl. Akad. Nauk*, 1958, 123, 262.

141. On the mechanism underlying the influence of slight admixtures of electrolytes on the strength of the crystal structure formed by solidification. E. E. SEGALOVA, *et al.*, *Dokl. Akad. Nauk.*, 1960, 133, 630.

142. On conditions for the reversibility of metal breakdown process under load. B. J. PINES and A. F. SIRENKO, *Dokl. Akad. Nauk*, 1960, 131, 1312.

143. Normal stress effect in the solution of rod-like macromolecules. TADAO KOTAKA, *J. Chem. Phys.*, 1959, 30, 1566-1567. Dept. of Industrial Chemistry, Kyoto University. Three components of normal stresses in a solution of rod-like macromolecules are calculated on the basis of the general theory of irreversible processes of macromolecular solutions developed by Kirkwood. The results are expressed in expansion series of even powers of the rate of shear and are explicitly given to their fourth powers. When the hydrodynamic interaction is not taken into account, two components of the normal stress perpendicular to the direction of flow identically vanish, while, by the introduction of this interaction, they appear. The action of normal stresses is still mainly "pull" in the direction of flow as in the free-draining case.

144. On an approximate theory of transport in dense media. S. A. RICE and J. G. KIRKWOOD*, *J. Chem. Phys.*, 1959, 31, 901. *Dept. of Chemistry, Yale University. A general statistical mechanical treatment involving some approximations. Absolute viscosity of liquid argon is estimated within a factor of 2.

145. On the stability of displacement fronts in porous media: a discussion of the Muskat-Aronofsky model. A. E. SCHEIDEGGER, *Canad. J. Phys.*, 1960, 38, 153-162. Imperial Oil Research Lab., Calgary, Alberta. The model is analysed in the light of the phenomenon of fingering. It demands that fingering occurs for mobility ratios (displaced/displacing fluid) smaller than one. The model also yields some conditions regarding the geometry of fingers, but for a complete description, the statistical geometry of the porous media must be considered.

146. Comparison of flow lines in various types of rheological bodies. SISIR CHANDRA DAS, *Canad. J. Phys.*, 1960, 38, 32-38. Indian Institute of Technology, Madras, India. An investigation of the nature of flow in Bingham bodies compressed by means of parallel rigid approaching plates. The results have been compared with those of plastic and viscous flow under the same conditions. It is shown that the flow lines in all three cases are very similar.

147. Measurements and theory of the concentration dependence of flow birefringence. H. JANESCHITZ-KRIEGL, *Makromol. Chem.*, 1960, 40, 140-147. Centraal Lab., TNO., Delft, Netherlands. A derivation of the known relations between stress and birefringence is given for dilute polymer solutions when solvent and solute refractive indices are equal.

SECTION A

For the case when these are unequal, the contribution from form birefringence is calculated from Copic's recent theory, the value of the excess polarizability being calculated from the rate-of-change of solution refractive index with concentration. Results thus obtained agree satisfactorily with the values (extra-polated to zero concentration) of the stress-optical coefficient previously measured by the author on solutions of polystyrene in four solvents of different refractive indices. A.S.L.

148. Tortuosity in porous media. P. B. LORENZ, *Nature, Lond.*, 1961, 189, 386-387. Petroleum Research Center, Bureau of Mines, U.S. Dept. of the Interior, Bartlesville, Oklahoma. Relationships between tortuosity and porosity are discussed.

149. Heat effects involved in the motion and stoppage of a flow of anomalously viscous bodies. V. P. PAVLOV and G. V. VINOGRADOV, *Dokl. Akad. Nauk*, 1959, 125, 1061.

150. The character of deformation at the yield point. I. M. GRIAZNOV, *Dokl. Akad. Nauk*, 1959, 126, 1250.

151. A new law in the fatigue failure of metals. V. S. IVANOVA, *Dokl. Akad. Nauk*, 1959, 127, 86.

152. Strain hardening of plastic bodies. D. D. IVLEV, *Dokl. Akad. Nauk*, 1959, 127, 777.

153. Flow of anomalously viscous systems under the action of two pure shears in mutually perpendicular directions. G. V. VINOGRADOV, A. A. MAMAKOV and V. P. PAVLOV, *Dokl. Akad. Nauk*, 1959, 127, 362.

154. On the mechanism underlying the failure of solids. S. N. SHURKOV and A. V. SAVITSKII, *Dokl. Akad. Nauk*, 1959, 129, 91.

155. Limit equilibrium of a plastically inhomogeneous wedge. B. A. DRUIANOV, *Dokl. Akad. Nauk*, 1959, 127, 990.

156. Approximate analysis of the stressed state of rubber samples tested for tear resistance by different methods. A. I. LUKOMSKAIA, *Dokl. Akad. Nauk*, 1959, 127, 1207.

157. Viscoplastic flow between rotating discs. A. M. GUTKIN, *Dokl. Akad. Nauk*, 1960, 134, 1048.

158. Simple theory of plasticity—its limitations. S. C. GOYAL and M. M. BATRA *J. Sci. Industr. Res.*, 1961, 20B, 10-15. M.B.M. Engineering College, Jodhpur, India. The limitations of Baker's theory of plasticity and the assumptions made therein are discussed, and a theoretical check has been made to find out whether the requisite rotation of the plastic hinge is actually possible to give the final moment redistribution. It has been found that hinge rotation required for full moment redistribution as per simple theory of plasticity cannot be attained on the basis of the assumed idealised stress-strain curve. Author

159. Periodical motions of a viscous incompressible fluid. V. I. IUDOVICH *Dokl. Akad. Nauk*, 1960, 130, 1214.

VOL.
4
1961

THEORETICAL

160. Deformation kinetics as related to the flexibility of the loading system. T. K. ZILOVA, N. I. PATRUKHINA and IA. B. FRIDMAN, *Dokl. Akad. Nauk.*, 1959, **124**, 1236.

161. The force of friction and the deformation of surfaces. V. D. EVDOKIMOV, V. S. RADCHIK and A. S. RADCHIK, *Dokl. Akad. Nauk*, 1959, **128**, 921.

162. Law of earthquake recurrence as a result of regularities in the deformation and crumbling of rocks. G. I. GUREVICH, I. L. NERSESOV and K. K. KUZNETSOV, *Dokl. Akad. Nauk*, 1959, **128**, 1163.

163. The fine structure of Rayleigh line and the propagation of the hypersound in high viscosity liquids. M. S. PESIN and I. L. FABELINKSI, *Dokl. Akad. Nauk*, 1959, **129**, 299.

164. The stability of the passive state of metals under stress. N. D. TOMASHOV and N. I. ISAEV, *Dokl. Akad. Nauk*, 1959, **126**, 619.

165. A thermodynamic investigation of the stress-strain relations in isotropic elastico-plastic media. A. A. VAKULENKO, *Dokl. Akad. Nauk*, 1959, **126**, 740.

166. A method for determining the rate and kinetic constants of complicated chemical reactions in a flow. G. M. PANCHENKOV *et al.*, *Dokl. Akad. Nauk*, 1960, **135**, 1172.

167. The direction of gliding and the work hardening of a surface. V. D. EVDOKIMOV, *Dokl. Akad. Nauk*, 1960, **136**, 74.

168. On highly thermoconductive flows. M. N. KOGAN, *Dokl. Akad. Nauk*, 1959, **128**, 488.

169. On coherent ground stability, as dependent on adhesion in the process of washing. Ts. E. MIRTSKHULAVA, *Dokl. Akad. Nauk*, 1959, **124**, 165.

170. The stability of the equilibrium of a solid having some cavities filled with a liquid. V. V. RUMIANSTEV, *Dokl. Akad. Nauk*, 1959, **124**, 291.

171. On the stability of a viscous film on a solid in a gas flow. A. A. ZAITSEV, *Dokl. Akad. Nauk*, 1960, **130**, 1228.

172. Equations of linearized space problems in the theory of ideal plasticity. D. D. IVLEV, *Dokl. Akad. Nauk*, 1960, **130**, 1232.

173. Fundamental equations for the flow of homogeneous fluids through fissured rocks. G. I. BARENBLATT and IU. P. ZHELTOV, *Dokl. Akad. Nauk*, 1960, **132**, 545.

SECTION A

174. Design of gasified liquid flows with a two-parameter characteristic of permeabilities. D. A. EFROS and I. F. KURANOV, *Dokl. Akad. Nauk*, 1960, 132, 553.

175. Oscillations in the wake of a moving body. V. N. ARKHIPOV, *Dokl. Akad. Nauk*, 1958, 123, 620.

176. Mechanism of the development of microcracks in crystals on plastic deformation. V. N. ROZHANSKY, *Dokl. Akad. Nauk*, 1958, 123, 648.

177. Wear of two rubbing surfaces unequal in size. V. D. EVDOKIMOV, *Dokl. Akad. Nauk*, 1960, 135, 573.

178. Systematic nature of departures from plasticity laws. N. M. MIKTRKHIN and I. I. IAGN, *Dokl. Akad. Nauk*, 1960, 135, 796.

179. Effect of uneven heating on stress variation in the state of creep. B. F. SHORR, *Dokl. Akad. Nauk*, 1958, 123, 809.

180. A partial solution of general ideal plasticity equations in cylindrical co-ordinates. D. D. IVLEV, *Dokl. Akad. Nauk*, 1958, 123, 988.

181. On flows produced by sound. K. A. NAUGOLYNKH, *Dokl. Akad. Nauk*, 1958, 123, 1003.

182. Equilibrium cracks formed on brittle fracture. G. I. BARENBLATT, *Dokl. Akad. Nauk*, 1959, 127, 47.

183. On theory of elastic oscillations of a solid containing a liquid. N. N. MOISEEV, *Dokl. Akad. Nauk*, 1959, 127, 51.

184. On a possibility of obtaining the exact integrals of Reynolds equation in closed form. J. M. KOTLIAR, *Dokl. Akad. Nauk*, 1959, 127, 59.

185. On the mechanism of long cumulative degradation and eventual failure of metals under load. B. J. PINES and A. F. SIRENKO, *Dokl. Akad. Nauk*, 1960, 134, 1061.

186. On the equation of compressible plastic medium dynamics, M. I. ESTRIN, *Dokl. Akad. Nauk*, 1960, 135, 36.

187. Methods for the computation of internal stresses in polymeric varnish coatings. A. T. SANZHAROVSKII, *Dokl. Akad. Nauk*, 1960, 135, 58.

188. The possible mechanism of glide line formation in the absence of localized sources of dislocation. E. D. SHCHUKIN, *Dokl. Akad. Nauk*, 1960, 135, 61.

189. On the construction of viscous fluid dynamics. D. D. IVLEV, *Dokl. Akad. Nauk*, 1960, 135, 280.

VOL.
4
1961

INSTRUMENTS AND TECHNIQUES

190. The mechanism underlying the wear of polymers by rubbing and the similarity criterion. S. B. RATNER, *Dokl. Akad. Nauk*, 1960, 135, 294.

Section B

INSTRUMENTS AND TECHNIQUES

191. The influence of viscometer design on non-Newtonian measurements. R. McKENNEL, *Trans. Soc. Rheol.*, 1960, 4, 366. Ferranti Ltd., Manchester, England. Methods of eliminating shear rate variations, and hence the tedium of applying corrections for non-Newtonian liquids are described.

192. Developments on paint viscometry. R. McKENNEL, *Paint Manufr.*, 1960, 30, 391-396, 402. Attention is drawn to the inadequacy of flow cups and many types of rotational viscometer for use with non-Newtonian fluids. The application of the Ferranti portable viscometer and the Ferranti-Shirley cone and plate viscometer in the interpretation of rheological data in terms of paint performance and in the control of paint thinning are discussed.

193. Verification of low loads in hardness testing machines. R. J. ELLIS, *J. Sci. Instrum.*, 1961, 38, 105. Division of Metrology, National Standards Lab., C.S.I.R.O., University Grounds, City Road, Chippendale, N.S.W., Australia. The indenter impinges on one end of a balance arm. Its force is determined from the weight required on the other arm to counteract it. W.G.C.

194. Evaluation of hot hardness measuring techniques and the development of a hot microhardness tester. L. P. WHITNEY, G. W. WEBB and R. A. GULICK, *U.S. Government Research Reports*, 1958, 29, 134. I.D.A.

195. Normal stresses in structural colloidal systems and the effect of thixotropic recovery of structure on them. A. A. TRAPEZNIKOV, A. S. MOROSOV and G. G. PETRZHIK, *Kolloidnyĭ Zh.*, 1960, 22, (6), 761. Inst. of Phys. Chem. Acad. Scis., Moscow. A method has been developed for investigating normal stresses in fluid colloidal systems. It has been shown that the normal stresses in a 2 per cent. aluminium naphthenate gel depend upon the time of thixotropic recovery of the structure. Normal stress-deformation curves have been shown to possess two maxima before transition to steady state flow. [Russian] English abstract.

Author

196. Temperature control in plastics testing. P. N. BESTELINK, R. MILLWOOD and C. E. STEPHENSON, *Plastics*, 1959, 24, 510-511. Plastics Division, Imperial Chemical Industries, Ltd. A device for producing the heating rate required for the Vicat softening point and heat distortion tests.

197. Device for measuring stress relaxation of plastics. R. J. CURRAN, R. D. ANDREWS, Jr. and F. J. MCGARRY, *Mod. Plastics*, 1960, 38(3), 142. Massachusetts Institute of Technology, Cambridge, Mass.

SECTION B

198. The testing of PVC coated fabrics. W. K. DALTON. *Plastics*, London, 1960, 25, 71-76. Storey Brothers Ltd., England. Describes standard methods of measuring physical properties, including tensile strength, tear strength, flex resistance, abrasion resistance and various low temperature resilience properties.

199. Some special test methods applicable to polyethylene. D. WESTON, *Plastics*, 1959, 24, 465-468. Bakelite Ltd., England. Tensile impact strength, rigidity modulus, yield strength, coefficient of friction, permittivity and other measurements are described.

200. Polyurethane foams. S. H. MORRELL, *Research*, 1959, 12, 412-416. Research Association of British Rubber Manufacturers, Shawbury, Shrewsbury, England. Stress strain and hysteresis curves are discussed.

201. Application of the ultracentrifuge to the study of synthetic high polymers I. J. H. S. GREEN and H. M. PAISLEY, *Research*, 1961, 14, 107-112. National Chemical Laboratory, Teddington, Middlesex.

202. Dynamic mechanical testing of polymers. G. C. KARAS and B. WARBURTON, *British Plastics*, 1961, 34, 131-137. British Resin Products, Sully, Glamorgan and Distillers Co., Epsom, Surrey. A survey of the fundamentals of non-destructive dynamic mechanical testing.

203. An apparatus for the measurement of gelation times. W. J. ROSS and C. H. WRIGHT, *British Plastics*, 1960, 33, 378-379. Techne (Cambridge) Ltd., Duxford, Cambridge, England.

204. Technique for measuring the elastic properties of bitumens, tars and soils under dynamic loading. E. N. THROWER, *J. Sci. Instrum.*, 1961, 38, 69-73. Road Research Laboratory, Harmondsworth, Middlesex. The measurement of the components of the complex Young's and rigidity moduli of bitumens, tars and soils up to about 10^{10} dyne cm.⁻² is described. A frequency range of 5 to 500 c/s and temperatures between -20° and +30°C may be employed. To measure the complex Young's modulus, an axial sinusoidally varying force is applied to a cylindrical specimen by a moving-coil vibrator. Piezoelectric gauges are used to convert the force applied to the specimen and the displacement of its driven end into voltages, which are measured on a phase-sensitive voltmeter. For the measurement of the complex rigidity modulus, the material is sheared in the annulus between two cylinders, the inner being driven by the vibrator. The same two gauges now serve to measure the force applied to the inner cylinder, its displacement and their relative phase. Author

205. The use of small specimens in cement testing. J. A. FORRESTER and R. A. KEEN, *J. Appl. Chem.*, 1960, 10, 358-365. Cement and Concrete Association, Stoke Poges, Bucks. New work on half-inch vibrated cube mortar testing is described.

206. An accelerated test for the 7 day and 28 day compressive strengths of concrete. J. W. H. KING, *J. Appl. Chem.*, 1960, 10, 256-262. Civil Engineering Dept., Queen Mary College, London. Sample cubes are

subjected to a standard heating procedure, and their immediate crushing strength measured. Correlation between these results and true 7 or 28 day strengths measured under carefully controlled conditions is better than the spread of results normally obtained on site with the 28 day test.

207. The use of internal friction method in studying the effects of surface-active medium on the deformation and failure of metals. N. V. DEKARTOVA and V. N. ROZHANSKII, *Dokl. Akad. Nauk*, 1959, 126, 602.

208. High pressure and high temperature apparatus with conical dies. L. F. VERESHCHAGIN, V. A. GALAKTIONOV, A. A. SEMERCHAN and V. N. SLESAREV, *Dokl. Akad. Nauk*, 1960, 132, 1059.

209. Determination of internal stresses in glue films between solid surfaces stuck together. C. A. SHREINER and P. I. ZUBOV, *Dokl. Akad. Nauk*, 1959, 124, 1102.

210. Investigation of the caking kinetics of nickel, copper and molybdenum powders by dilatometry. R. S. MINTS, *Dokl. Akad. Nauk*, 1959, 124, 1240.

211. Some experimental investigations into the dynamics of soft grounds. V. D. ALEXEENKO, *et al.*, *Dokl. Akad. Nauk*, 1960, 133, 1311.

212. Bauschinger's effect in the case of sliding friction. A. S. RADCHIK and V. D. EVDOKIMOV, *Dokl. Akad. Nauk*, 1960, 134, 571.

213. Measurement of the shearing stresses of a number of substances at up to 100,000 atm pressures. L. F. VERESHCHAGIN and E. V. ZUBOVA, *Dokl. Akad. Nauk*, 1960, 134, 787.

214. Fluid mixing in agitated vessels. A. B. METZNER, *Trans. Soc. Rheol.*, 1960, 4, 364. University of Delaware, Newark, Delaware. Fluid motion in an agitated tank has been studied by following the motion of tracer particles in both Newtonian and non-Newtonian fluid systems. The contents of the vessel consist of two portions, a small, perfectly mixed region near the impeller, and a surrounding region in which turbulent mixing rates are nearly zero. The model is obeyed particularly closely in non-Newtonian fluids.

215. Measuring oil film thickness in a crankshaft main bearing of a V-8 engine. W. D. SIMS, *Lubric. Engng.*, 1961, 17, 123-126. Shell Development Co., Emeryville, Calif. Thickness measurements were made whilst the engine was operating. Operation was normal except for the maintenance of a constant oil pressure. The maximum and minimum thicknesses observed during a revolution of the crankshaft were affected only slightly by speed, but they each decreased linearly with increase in engine power (at constant speed). Oil viscosity, covering a range of 4.6 to 15 cs at the test temperature, had no effect on the thickness-power relationships. Also, no difference was observed between Newtonian and non-Newtonian oils. It is suggested that at a given load condition the thermal balance of the bearing is such that a constant viscosity is achieved within the bearing.

J.F.H.

SECTION C

Section C

METALS AND OTHER SOLIDS

216. Brittle lacquers. J. R. LINGE, *Research*, 1960, **13**, 18-25. King's College, University of Durham. The brittle lacquer technique is described with everyday examples. Factors influencing the behaviour of lacquers and attempts to overcome difficulties in their applications are discussed. Various uses of lacquers in detecting stress and fatigue cracks are illustrated.

217. Static fatigue of some strained materials suffering corrosive cracking. Iu. S. ZUEV and A. Z. BORSHCHEVSKAIA, *Dokl. Akad. Nauk*, 1959, **124**, 613.

218. Effect of nuclear particle bombardment on stresses and small deformations in solids. Iu. I. REMMEV, *Dokl. Akad. Nauk*, 1959, **124**, 540.

219. Role of microstresses in the plastic deformation of solids. D. M. VASIL'EV and G. I. ARKOVENKO, *Sov. Phys. Solid State*, 1960, **2**, 507-510. [Russian]

220. Properties of stressed bone. C. J. DREYER, *Nature, Lond.*, 1961, **189**, 594-595. Univ. of the Witwatersrand and C.S.I.R., Johannesburg, South Africa. Birefringence has been observed in bones subjected to stress, and this is discussed with respect to possible future research.

W.G.C.

221. The cracking activity in ice during creep. L. W. GOLD, *Canad. J. Phys.*, 1960, **38**, 1137-1148. Building Research Division, N.R.G., Ottawa, Canada. Observations were made at one temperature on the cracks that form in ice during creep under constant compressive load. The ice had a hexagonal symmetry with respect to the grain boundaries. The load was applied perpendicular to the long axis of the grains. Two stages of cracking were observed. The first occurred during the transient period of the creep, and the plane of these cracks tends to be parallel to the grain boundaries and to the direction of the stress. The rate at which these cracks formed decreased very markedly as the creep rate approached a constant value. Above a certain stress, the creep rate continuously increased with time. Then the second stage of cracking was observed. These cracks tend to be more irregular in direction and to occur in planes that are at 45° to the applied stress.

222. Variation of the elastic constants of quartz filaments in response to gamma radiation from cobalt 60. S. V. STARODUBSTEV, L. P. KHIZNICHENKO, I. A. DOMORIAD, *Dokl. Akad. Nauk*, 1960, **132**, 803.

223. Strengthening of glass by treatment with organosilicon compounds. S. I. SIL'VESTROVICH and I. A. BOGUSLAVSKII, *Dokl. Akad. Nauk*, 1959, **129**, 1362.

224. On the mechanical strength of ceramic materials. V. G. BRAVINSKII, *Dokl. Akad. Nauk*, 1960, **131**, 82.

225. High strength glass. D. G. HOLLOWAY and P. A. P. HASTILOW, *Nature, Lond.*, 1961, **189**, 385-386. Physics Dept., University College of North Staffordshire, Keele. Two methods have been used to prepare fibres of diameter 350-700 μ which are free from visible defects, and these have been tested in 3-point bending using a gauge length of 7 mm. The fibres were produced by hand drawing $\frac{1}{2}$ in. diameter commercial and "Pyrex" rod which were etched in 20 per cent hydrofluoric acid immediately before or after drawing. It is concluded that the high and relatively consistent values of the breaking strength obtained support quantitatively the previous indication that the visible defects are a major source of surface weakness. W.G.C.

226. Dislocation type defects in glass. W. C. LEVENGOOD and T. S. VONG, *J. Chem. Phys.*, 1959, **31**, 1104-1110. Ball Brothers Research Corp., Muncie, Indiana. The reaction of flaws on freshly broken glass surfaces to applied stress is similar to that exhibited by dislocation type defects. Spherical indenters were used to produce controlled shear stresses.

227. Causes responsible for the reduction of the strength of monocalcium aluminate crystal structure formed at high temperature. E. E. SIGALOVA, Z. D. TULOVSKAIA, E. A. AMELINA and P. A. REBINDER, *Dokl. Akad. Nauk*, 1959, **124**, 876.

228. The dependence of the grinding process on the physical and mechanical properties of the ground crystals. N. N. KACHALOV and L. F. GRIGORIEVA, *Dokl. Akad. Nauk*, 1959, **129**, 1012.

229. Jumplike movement of dislocations in NaCl crystals. V. N. ROZHANSKII and V. M. STEPANOVA, *Dokl. Akad. Nauk*, 1960, **133**, 804.

230. Effects of plastic deformation on internal friction and rigidity modulus in silver chloride. I. U. KH. VEKILOV and M. P. SHASKOL'SKAIA, *Dokl. Akad. Nauk*, 1959, **128**, 71.

231. The relation between the degree of metamorphism of coals, and their elasticity modulus. E. G. MARTYNOV and A. K. MATVEEV, *Dokl. Akad. Nauk*, 1960, **135**, 427.

232. Influence of water upon the strength of concrete. A. M. ARKHIPOV, K. A. MAL'TSOV, I. B. SOKOLOV and P. G. STARITSKII, *Dokl. Akad. Nauk*, 1959, **125**, 359.

233. Main design problem on cohesion between reinforcement of periodical cross-section and concrete in centrally reinforced prismatic elements. M. M. Kholmianskii, *Dokl. Akad. Nauk*, 1959, **129**, 48.

234. Distortion of the graphite lattice in the process of mechanical dispersion. L. A. FEIGIN, *Dokl. Akad. Nauk*, 1959, **127**, 313.

SECTION C

235. Properties of graphite. I. Preparation, structure and mechanical properties. L. C. F. BLACKMAN, *Research*, 1960, 13, 390-397. Dept. of Chemical Engineering, Imperial College of Science and Technology, London. Hardness, friction, compressibility, modulus and tensile strength are discussed.

236. Properties of graphite. III. Crystal compounds and irradiated graphite. L. C. F. BLACKMAN, *Research*, 1960, 13, 492-502. Dept. of Chemical Engineering, Imperial College of Science and Technology, London. The effect of irradiation in causing a permanent set in stressed graphite is described.

237. Fracture testing of high-strength sheet materials. Report of Special A.S.T.M. Committee. *A.S.T.M. Bull.*, No. 243, pp. 29-39 (for Part 1); *A.S.T.M. Bull.*, No. 244 (for Part 2). When high tensile strength alloys are used at high stress levels (as in solid propellant rocket casings) they are likely to behave in a brittle manner in the presence of small flaws. At present there is no standardised test for measuring the resistance of such sheet materials to crack propagation. Methods of measuring "fracture toughness" are described based upon centrally slotted or edge notched tensile specimens. The values obtained can be used to calculate conditions for fracture in stressed sheets in the presence of flaws of known length. Methods of calculation are given and data on several alloys tabulated.

238. The effect of corrosion inhibitors on the wear of metals. E. M. ZARETSKII *et al.*, *Dokl. Akad. Nauk*, 1960, 135, 890.

239. Arc metals hardened by cutting when lubricants are used ? V. D. KUZNETSOV and A. I. LOSKUTOV, *Dokl. Akad. Nauk*, 1958, 123, 273.

240. Surface activity of liquid metal coatings and their influence on the strength of metals. N. V. PERTSOV and P. REHBINDER, *Dokl. Akad. Nauk*, 1958, 123, 1068.

241. Absorption interaction and mechanical properties of lubricant layers as factors in pressure processing of metals. V. M. KORBUS and S. J. VEILER and V. I. LICHTMAN, *Dokl. Akad. Nauk*, 1960, 130, 307.

242. On the plasticity of high-temperature modifications of polymorphous metals. E. M. SAVITSKII, CH. V. KOPETSKII, *Dokl. Akad. Nauk*, 1960, 131, 1137.

243. Yield point lowering in thin surface layer of metal in wire drawing as affected by the dose of the surface-active substance added. V. M. KORBUS, *Dokl. Akad. Nauk*, 1959, 124, 72.

244. Grain growth and creep in metals. K. A. OSIPOV, *Dokl. Akad. Nauk*, 1959, 128, 52.

245. The effect of surface active media on the strain hardening of metal surfaces. G. I. EPIFANOV, N. I. GLAGOLEV and P. REHBINDER, *Dokl. Akad. Nauk*, 1958, **123**, 663.

246. The microstructure of stresses in slip lines and dislocations. V. L. INDENBOM and G. E. TOMILOWSKY, *Dokl. Akad. Nauk*, 1958, **123**, 673.

247. Relaxation processes in the recovery and low tempering of hardened steel. V. I. SARRAK and P. I. ENTIN, *Dokl. Akad. Nauk*, 1959, **127**, 306.

248. Phasic work hardening of austenite. O. P. MAXIMOVA and E. I. ESTRIN, *Dokl. Akad. Nauk*, 1960, **132**, 1303.

249. The effect of adsorption in reducing the strength of steels in melts. K. F. KOSOGOV and V. I. LICHTMAN, *Dokl. Akad. Nauk*, 1960, **134**, 81.

250. Effect of air pressure on the fatigue of lead and aluminium. K. U. SNOWDEN, *Nature, Lond.*, 1961, **189**, 53-54. Baillieu Laboratory, Metallurgy School, Univ. of Melbourne, Australia. The fatigue life in reverse plane bending of aluminium was found to increase steadily with decrease in air pressure. That of lead was independent of air pressure at high and low levels, but in the intermediate range (0.15 mm—5.10⁻² mm. Hg) the fatigue life of lead increased rapidly with decreasing pressure. These results are discussed in relation to the propagation of cracks. W.G.C.

251. Effect of a preliminary deformation on the plasticity of aluminium. V. D. KUZNETZOV and A. I. LOSKUTOV, *Dokl. Akad. Nauk*, 1959, **126**, 70.

252. X-ray microbeam study of deformation bands in aluminium. D. LEWIS, *Brit. J. Appl. Phys.*, 1960, **11**, 162. Battersea College of Technology. To assess the effect of plastic bending and mosaic structure on asterism, microbeam photographs were taken across a deformation band in an aluminium crystal and the total curvature compared with that from a normal X-ray beam. It is concluded that the asterism is due to fragmentation.

253. Control of irradiation embrittlement in molybdenum. D. N. SETHNA, A. A. JOHNSON, K. J. PROUD and S. S. SHEININ, *Nature, Lond.*, 1960, **189**, 568. Metallurgy Dept., Imperial College of Science and Technology, London, S.W.7. Murex sintered molybdenum was irradiated with neutrons before testing with a modified Hounsfield tensometer operating at a strain rate of 0.88×10^{-4} sec.⁻¹. From these and similar measurements on the unirradiated material, the ductile-brittle transition temperatures were determined. The transition temperature for materials before and after irradiation was $120^\circ\text{C} \pm 10^\circ$, while the shape of the load-extension curve at any temperature was also unaltered. W.G.C.

254. Anisotropy in the broadening of X-ray diffraction maxima of solid copper solutions after deformation. L. N. GUSEVA and A. A. BABAREKO, *Dokl. Akad. Nauk*, 1959, **124**, 789.

SECTION C

255. The mechanism of a reciprocal transfer of copper when bronze is in rubbing contact with steel. D. N. GARKUNOV *et al.*, *Dokl. Akad. Nauk*, 1960, 133, 1128.

256. Superplasticity of brass LS 59-1 alloyed with cerium. E. M. SAVITSKII and U. K. DUSEMALIEV, *Dokl. Akad. Nauk*, 1960, 131, 817.

257. Brittle rupture of zinc single crystals. E. D. SHCHUKIN and V. I. LIKHTMAN, *Dokl. Akad. Nauk*, 1959, 124, 307.

258. The brittle rupture of pure and alloyed zinc single crystals. L. A. KOCHANOVA, I. A. ANDREEVA and E. D. SHCHUKIN, *Dokl. Akad. Nauk*, 1959, 126, 1304.

259. Effects of cyclic heat treatment constants on the mechanical and physical properties of zinc. V. D. KUZNETSOV, A. I. SURNACHEVA and L. P. ROZHKOVA, *Dokl. Akad. Nauk*, 1949, 128, 927.

260. Regularities in the creep of single zinc crystals in the presence of surface-active easily fusible metal melt. V. A. LABZIN and V. I. LICHTMAN, *Dokl. Akad. Nauk*, 1959, 129, 536.

261. Strength reduction by adsorption and brittle failure of zinc and cadmium single crystals. Iu. V. GORIUNOV, N. V. PERTSOV and P. A. REHBINDER, *Dokl. Akad. Nauk*, 1959, 127, 784.

262. The effect of tin melt on the fatigue strength of steel samples with stress concentrators. M. I. CHAEVSKII, *Dokl. Akad. Nauk*, 1959, 124, 1049.

263. The structural and mechanical properties of single tin crystals as affected by a strongly adsorption-active medium. Iu. V. GORIUNOV *et al.*, *Dokl. Akad. Nauk*, 1959, 128, 269.

264. Elastic properties of cerium as influenced by hydrostatic pressure. F. F. VORONOV *et al.*, *Dokl. Akad. Nauk*, 1960, 135, 1104.

265. Some phenomena observed when single antimony crystals are in a state of strain. L. M. SOIFER and V. I. STARTSEV, *Dokl. Akad. Nauk*, 1960, 134, 795.

266. Relationship between indentation hardness and normal elasticity modulus in titanium alloys at high temperatures. S. C. FEDOTOV and V. S. MIKHEEV, *Dokl. Akad. Nauk*, 1959, 128, 933.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

267. The glass temperature of semicrystalline polymers. S. NEWMAN and W. P. COX, *J. Polym. Sci.*, 1960, 46, 29-49. Monsanto Chemical Company, Springfield, Massachusetts, U.S.A. The influence of crystallinity, orientation and stereospecificity on the glass transition temperature

Tg has been studied for crystallizable polystyrene and polypropylene using dynamic mechanical and thermal distortion methods. In the latter method the apparent Tg depends largely on the conditions of test. In polystyrene, an increase in Tg of 5–15°C is observed on crystallization in the unoriented condition and an increase of 15–25°C if the specimen is oriented. A mechanism is proposed to account for this behaviour. Stereospecificity appears to have negligible influence on Tg.

268. Mechanism underlying the increase of fatigue strength of elastoplastic materials liable to harden on cyclic deformation due to the action of strong surface active compounds. M. I. CHAEVSKII, *Dokl. Akad. Nauk*, 1959, 125, 319.

269. An investigation of the adhesion of a polymer to modified glass surfaces in connection with the reversal of its charge sign in tearing off. N. A. KROTOVA, L. P. MOROZOVA and B. V. DERIAGIN, *Dokl. Akad. Nauk*, 1959, 129, 149.

270. Reversible radiation—mechanical effects in polymers. M. A. MOKUL'SKII, I. U. S. LAZURKIN, M. B. FIVEISKII and V. I. KOZIN, *Dokl. Akad. Nauk*, 1959, 125, 1007.

271. Mechanical characteristics of the adhesion of polymers. N. A. KROTOVA, L. P. MOROZOVA and G. A. SOKOLINA, *Dokl. Akad. Nauk*, 1959, 127, 302.

272. An experimental investigation of stress distribution in the process of polymer rupture. V. E. GUL and I. M. CHERNIN, *Dokl. Akad. Nauk*, 1958, 123, 713.

273. Conformation of the stretched polymer chain. YU. YA. KOLBOVSKII, *Vysokomol. Soedineniya*, 1960, 2, 144–147. [Russian, English summary]

274. The study of the polydispersity of polymers by viscometry. J. L. LUNDBERG, M. Y. HELLMAN and H. L. FRISCH, *J. Polym. Sci.*, 1960, 46, 3–17. Bell Telephone Laboratories, Murray Hill, New Jersey, U.S.A. A viscometric index of polydispersity is defined, being given by the ratio of the viscosity-average molecular weights in a relatively good and a relatively poor solvent respectively, minus unity. The behaviour of this index was studied using polydisperse samples of polystyrene and polymethyl-methacrylate and its sensitivity to changes in polydispersity determined. It is concluded that the viscometric index is valuable in characterizing the polydispersity of linear polymers and rough fractions.

275. Polymeric melts—a study of steady state flow, extrudate irregularities and normal stresses. A. B. METZNER, E. L. CARLEY and I. K. PARK, *Mod. Plastics*, 1960, 37(11), 133–140. Dept. of Chemical Engineering, University of Delaware, Newark, Del. U.S.A. Extrusion properties of polyethylene and polypropylene are compared, and related to normal stress measurements.

SECTION D

276. General formula for creep and rupture stresses in plastics. S. GOLDFEIN, *Mod. Plastics*, 1960, 37(8), 127. Materials Branch, USAERDL, Fort Belvoir, Va. Rupture properties of polymers over the time range 0.01 second to 40,000 hours can be predicted from the parameter K , where

$$K = ToT(20 + \log t)/(To - T)$$

where To is the zero strength temperature, T the operating temperature and t the time.

277. Behaviour of thermoplastics under prolonged stress. S. PASTONESI, *Materie Plastische*, 1959, 1028, *Plastics, Lond.*, 1960, 25, 111. Tensile tests are reported on tubes of polythene, acrylonitrile-butadiene-styrene and rigid PVC after long periods of internal pressure at high temperatures. Temperatures ranged from 10° to 70°C, pressures up to 560 kg/cm² and exposure up to 100,000 hours.

278. Energy requirements of mechanical shear degradation in polymer solutions. A. B. BESTUL, *J. Chem. Phys.*, 1960, 32, 350-356. National Bureau of Standards, Washington. 10 per cent solutions of polyisobutylene of molecular weight above 500,000 were forced through a capillary at nominal rates of shear above 10,000 sec⁻¹. The amount of degradation was compared with estimates of the energy dissipated during flow which contributed to the degradation process. Several hundred thousand kilocalories per mole of broken bonds are required; and it is suggested that this energy is stored in a comparatively large volume around each broken bond and is dissipated when the bond breaks.

279. Reinforcing action of glass and organic fibres in epoxy laminates. C. D. DOYLE, *Mod. Plastics*, 1959, 37(3), 143-148. General Electric Co. U.S.A. Whereas glass contributes stiffness and strength to laminates, Dacron contributes flexibility and toughness. The toughness contribution is especially apparent in impact tests. Thermal expansion tests, dynamic mechanical tests and stress relaxation tests at elevated temperatures all show that Dacron contributes added stiffness at temperatures above the softening point of the resin matrix. The stiffening effect of Dacron at elevated temperatures is small and short lived, however, compared to that of glass.

Author

280. How to predict structural behaviour of RP laminates. L. FISCHER, *Mod. Plastics*, 1960, 37(10), 120-128. Grumman Aircraft Corp., Bethpage, N.Y. Stress strain relationships are presented for a single layer of fibrous glass, and used to obtain stress distributions in a multi layer laminate. The procedure is shown to be simpler for an isotropic laminate. An interaction equation can predict failure in each layer of a laminate.

281. Plastics in missiles. 2. Thermal and strength requirements for reinforced plastics. A. W. WILSON, *British Plastics*, 1960, 33, 352-355. Bristol Aerojet Ltd., Banwell, England.

282. A comparison of polyester and epoxide resins in reinforced plastics. L. H. VAUGHAN, *British Plastics*, 1960, 33, 150-153. Bakelite Ltd..

Birmingham, England. Creep, impact strength, and other mechanical properties are compared.

283. Estimation of long time performance of extruded plastic pipe from short time burst strength. S. GOLDFEIN, *Mod. Plastics*, 1960, 37(9), 139. Materials Branch USAERDL, Fort Belvoir, Va.

284. Thermal and shear degradation in polyethylene extrusion. H. SCHOTT and W. S. KAGHAN, *Mod. Plastics*, 1960, 37(7), 116. Olin Mathieson Corp., New Haven, Conn. Repeated extrusion of the same material showed that all polyethylenes undergo degradation when extruded at higher than normal temperatures, and some degrade at the standard extrusion temperature.

285. Melt viscosity of polyethylene at zero shear. L. H. TUNG, *J. Polym. Sci.*, 1960, 46, 409-422. Polychemicals Research Dept., High Pressure Laboratory, The Dow Chemical Co., Midland, Michigan, U.S.A. Melt viscosities of polyethylene fractions were measured at low rates of shear in a cone and plate rotational viscometer and extrapolated to zero-shear viscosity (η). Both high and low density polyethylene obey the equation:

$$\log \eta = 3.4 \log \bar{M} \bar{\omega} - C(T)$$

where $\bar{M} \bar{\omega}$ is the light scattering molecular weight. The effect upon η of molecular branching in the low density polymer is discussed.

286. The endurance of polythene under constant tension while immersed in Igepal. W. A. DUKES, *British Plastics*, 1961, 34, 123-125. Ministry of Aviation, E.R.D.E., Waltham Abbey, Essex.

287. Mechanism of viscoelastic absorption in polyethylene at higher temperatures than room temperature. (Letter to the Editor), *J. Polym. Sci.*, 1960, 46, 531-534. The mechanical dispersion observed at about 350°K in polyethylene is attributed to frictional energy dissipation within crystalline regions rather than to the melting of those regions as generally supposed. Evidence from X-ray diffraction and dynamic tests over the temperature range 0-140°C supports this interpretation.

288. Time-dependent tensile strength of solids. I. H. HALL, *Nature, Lond.*, 1961, 189, 131. British Rayon Research Assn., Heald Green Labs., Wythenshawe, Manchester, 22. The tensile properties of isotactic polypropylene are presented over six decades of strain-rate from 10^{-4} to 10^4 sec. $^{-1}$ at 20°C. These figures reveal that though the conclusions of HSAIO (cf. *Rheology Abstracts*, 1960, 3(3), 328) might be applicable to this material in the range of strain-rates in which he worked (10^{-2} sec. $^{-1}$), they are certainly inapplicable in a range which extends to higher rates of deformation.

W.G.C.

289. Ethylene-butene copolymers. J. E. PRITCHARD, R. M. MCGLAMERY and P. J. BOEKE, *British Plastics*, 1960, 33, 58-61. Phillips Petroleum Co., U.S.A. The effect of temperature and strain rate on a number of mechanical properties is reported.

SECTION D

290. An investigation of the deformation of polyethyleneterephthalate crystal films. P. V. KOZLOV, *Dokl. Akad. Nauk*, 1959, **125**, 118.

291. Physical properties of vinyl polymers. R. B. BEEVERS and E. F. T. WHITE, *Trans. Farad. Soc.*, 1960, **56**, 1529-1534. Courtaulds Limited, Research Laboratory, Lower Cookham Road, Maidenhead, Berks. The glass-transition temperature of methyl methacrylate and acrylonitrile block and random copolymers is shown to be sensitive to the structural arrangement in the copolymer. Block copolymers have glass temperatures which are intermediate between those of polyacrylonitrile and polymethylmethacrylate whereas the random copolymers have glass temperatures which fall below that of either homopolymer. Results show that the acrylonitrile block, to a large extent, governs the properties of the block copolymer. W.H.B.

292. Flexural strength of polymethyl methacrylate at various deflection rates. R. E. ELY, *Mod. Plastics*, 1960, **37**(6), 138. Ordnance Missile Laboratories, Redstone Arsenal, Ala. Stress-strain rate curves for PMMA are given for compression, tensile and flexure rates from 0.002 to 200 min⁻¹ at 32° and 122°F.

293. Copolymers of methyl methacrylate and styrene for moulding and extrusion. T. E. DAVIES, *British Plastics*, 1960, **33**, 195-198. Distrene Ltd., Barry, Glamorgan. Various mechanical properties are listed.

294. Determination of internal viscosity of a polystyrene by streaming birefringence. C. WOLFF, *J. Chim. phys.*, 1960, **57**, 712-716. [French]

295. The vacuum forming of biaxially oriented polystyrene. A. S. MATTHEWS and G. HULSE, *British Plastics*, 1960, **33**, 463-467. Monsanto Chemicals Ltd., Fulmer, Bucks, England. Various mechanical data are given.

296. Rheological study of vinyl calendaring compounds. W. E. WOLSTENHOLME and P. E. ROGGI, *Mod. Plastics*, 1960, **37**(7), 131. Naugatuck Chemical Division, U.S. Rubber Co. The effects of M.W. and plasticiser content on the rheological properties of PVC compounds at several processing temperatures were studied using a shearing disc viscometer. An empirical relationship was found between viscometer reading, M.W., temperature and plasticiser content. The application to calendaring problems is discussed.

297. Factors affecting the bursting behaviour of hard PVC pipe at elevated temperatures. A. A. VAN DER WAL, *Plastics*, 1960, **25**, 361. N.V. Wavin, Zwolle, Holland.

298. Viscosity-molecular weight relationship for polyvinyl acetate. MASAKAZU MATSUMOTO and YASUZI OHYANAGI, *J. Polym. Sci.*, 1960, **46**, 441-454. Research Laboratory, Kurashiki Rayon Co., Ltd., Kurashiki, Okayama, Japan. The relation between limiting viscosity number and molecular weight of polyvinyl acetate was determined and compared with results obtained by other authors. The weight average molecular weights

were determined by light scattering and the number average molecular weights by end group determinations and osmotic pressures. The ratio $M_w \sqrt{M_n}$ was found to equal 2 as predicted by theory. The dependence of viscosity upon \bar{M}_w is given for various solvents.

299. The properties of nylon 11. J. G. HAWKINS, *Plastics*, 1960, **25**, 299-301. Whiffen and Sons. Many mechanical and rheological properties are listed.

300. Effect of swelling on the hydrogen-bonding and elastic behaviour of polyamides and poly-urethanes. K.-H. ILLERS and H. JACOBS, *Makromol. Chem.*, 1960, **39**, 234-237. [German]

301. Some problems concerning cure temperature effects on the strength of polyisoprene rubber stocks. A. V. RUDNEVA, *Dokl. Akad. Nauk*, 1959, **125**, 366.

302. On the structure and mechanical properties of amorphous polymers. M. V. WOLKENSTEIN, *Dokl. Akad. Nauk*, 1959, **125**, 523.

303. Irreversible flow of rubber-like polymers. G. M. BARTENEV, *Dokl. Akad. Nauk*, 1960, **133**, 88.

304. Regularities in the deformation behaviour of rubbers and raw rubber mixtures when compressed uniaxially. B. I. GENGRINOVICH, *Dokl. Akad. Nauk*, 1960, **134**, 400.

305. Relation between rupture and tear in rubber. M. M. REZNIKOVSKII and A. I. LUKOMSKAIA, *Dokl. Akad. Nauk*, 1959, **128**, 75.

306. Polymer solutions : VI. Single parameter evaluation of molecular weights from viscosity measurements. S. GUNDIAH and S. L. KAPUR, *J. Sci. Industr. Res.*, 1961, **20B**, 18-21. National Chemical Laboratory, Poona, India. A new method is suggested for calculating molecular weights of high polymers from viscosity measurements. It consists in the extrapolation of the plots of $\frac{1}{\eta} \ln \eta$ versus C in different solvents so as to

meet at a common point of intersection. The ordinate at the point of intersection is shown, semi-empirically, to be related to the molecular weight by the relation $(\eta)_R = KM^{\frac{1}{2}}$, where K is a constant independent of the solvents used and (η) represents the ordinate at the common point of intersection. The validity of this method has been checked with data available in the literature. Author

307. The tensile properties of twisted single fibres. R. W. DENT and J. W. S. HEARLE, *Text. Res. J.*, 1960, **30**, 805. Department of Textile Industries, Manchester College of Science and Technology, University of Manchester, England. Single fibres were twisted to various amounts prior to tensile testing. The variations with twist in tenacity, breaking extension, modulus and contraction or contractive stress on twisting have thus been measured. Experiments were carried out for both constant

SECTION D

tension and constant length twisting; subsidiary experiments show the effect of other factors. The results are compared with those of other workers; explanations of them are offered. Author

308. The mechanical properties of set wool fibres and the structure of keratin. M. FEUGHELMAN, *J. Text. Inst.*, 1960, **51**, T589. C.S.I.R.O., Ryde, New South Wales, Australia. Measurements were made of the load-extension curve in water at 20°C for wool fibres, which had been held strained at a range of extensions and times in boiling water, and released in water at various temperatures for one hour. The load-extension curves obtained showed considerable modification of the initial portion when compared with the curves for untreated fibres. The amount of modification depended on (a) the setting strain, (b) the time for which the fibre was held at the setting strain and (c) the temperature at which the fibre was released after setting. The modification of the mechanical properties of the wool fibre produced by the setting process can be explained in terms of a series zone model, which has already been proposed to explain other physical properties of keratin fibres.

Author

309. The measured properties of the ortho and para-like components of Lincoln wool fibres. M. FEUGHELMAN and A. R. HALY, *Text. Res. J.*, 1960, **30**, 805. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Ryde, N.S.W., Australia. The mechanical properties of Lincoln wool fibres in which the para-like portion of the wool fibre has been removed by abrasion have been compared with the properties of the same fibres unabraded. Results of tests in water at 20°C indicate that the stress-strain curve in the yield region is considerably different in slope for an unabraded as against an abraded fibre. This result, together with other lesser mechanical differences can be explained in terms of a difference of packing between the para-like and ortho-like components of a wool fibre. At PH1 mechanical tests show a major reduction in these mechanical differences, suggesting that the packing in para-like wool components is mainly dependent on salt linkages.

Author

310. Physical properties of wool fibres at various regains. Part 1: Stress developed at constant strain due to regain change by absorption or desorption. A. R. HALY and M. FEUGHELMAN, *Text. Res. J.*, 1961, **31**, 131. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Ryde, N.S.W., Australia. The paper reports determinations of stress changes which take place in wool fibres held at constant extension of 1.5 or 20 per cent and subjected to various relative humidity changes. Stresses may be very different according as equilibrium at a given relative humidity is approached by absorption or desorption of water by the fibre. At 1.5 per cent strain, when approach was by absorption, for all relative humidities used the stress fell to a level lower than when the fibre was in water, and then increased. A qualitative explanation is given in terms of changes analogous to sol-gel transformations.

Author

311. Physical properties of wool fibres at various regains. Part 2. Recovery from extension. A. R. HALY and M. FEUGHELMAN, *Text. Res. J.*,

1961, 31, 131. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Ryde, N.S.W., Australia. Under all conditions of extension and relative humidity which were used, length recovery took place in two stages: an early rapid recovery was followed by a slow recovery which was, in most circumstances, linear with log (time). The amount of rapid recovery depends on the stress in the fibre at the instant of release. Recovery from 20 per cent strain is greatly accelerated as relative humidity increases above 60 per cent; this is probably due to a sharp increase in the amount of free water in the wool fibre. Recovery from 1.5 per cent strain is different in character and the reason may be that the recovery from low strain contains a large elastic component.

Author

312. Stress changes at constant strain and hydrogen bonding in keratin fibres. A. R. HALY and M. FEUGHELMAN, *J. Text. Inst.*, 1960, 51, T573. C.S.I.R.O., Ryde, New South Wales, Australia. When a keratin fibre is extended in water, held and dried, a stress develops in the fibre. This stress is minimal for an extension of approximately 2 per cent. The strain dependence of developed stress, and some properties of fibres at strains in the region of 2 per cent are discussed in terms of postulated hydrogen bond formations. Data are included on swelling, on deuterium for hydrogen exchange in strained fibres, on recovery of length and on attempts to determine stress against strain curves under conditions in which fibre regain remained constant while the curves were determined.

Author

313. The breakage of twisted yarns. J. W. S. HEARLE and V. M. THAKUR, *J. Text. Inst.*, 1961, 52, T49. Manchester College of Science and Technology, Manchester. The modes of breakage of twisted continuous filament yarns are examined and it is found that, for short specimens and slow rates of loading, the break occurs in two distinct stages. Yarns in which only the first stage of break has taken place are examined and the mechanism of breakage is discussed. The effects of buckling, filament deformation and migration on breaking extension are examined.

Author

314. Influence of side chain hydrogen bonds on the elastic properties of protein fibres and on the configurations of proteins in solution. HAROLD A. SCHEREGA, *J. Phys. Chem.*, 1960, 64, 1917. Dept. of Chemistry, Cornell University, Ithaca, New York. A theory has been developed to account for the effect of various chemical agents, specifically pH but also salt, urea, etc.; on the elastic properties of protein fibres and on the configurations of proteins in solution. In both cases hydrogen bonds between polar side-chain groups are assumed to provide stabilisation of the crystalline form (e.g. α -helix) compared to the amorphous form (e.g. random coil) of the protein. The presence of such side-chain hydrogen bonds affects the thermodynamics of the crystalline \rightleftharpoons amorphous phase equilibrium. Equations are presented for the effect of pH on the equilibrium, and numerical calculations are carried out for several illustrative types of side-chain hydrogen bonds. Application of the theory to experimental data on the pH-dependence of the elastic properties of protein fibres or of reversible denaturation in solution may aid the identification

SECTION D

of the side-chain groups involved in hydrogen-bonding stabilization of the native protein. Author.

315. The relation between crystallite orientation and mechanical properties of mercerized cottons. B. R. SHELAT, T. RADHAKRISHNAN and B. V. IYER, *Text. Res. J.*, 1960, 30, 805. The Ahmedabad Textile Industry's Research Association, Ahmedabad—9, India. Bundles of cotton fibres have been mercerized at various controlled stretches. The X-ray orientation factor, static elastic modulus and load extension behaviour of these fibres have been determined. The effect of changes in fine structure on changes in mechanical properties is discussed in terms of the above data.

Author

316. The streaming birefringence of cellulose micelles: a confirmation of the theory for rigid rods. D. F. MACLENNAN and S. G. MASON, *Canad. J. Chem.*, 1959, 37, 1788–91. Department of Chemistry, McGill University, Montreal, Canada.

317. Studies on polyoxypropylene glycols. IV. Elastic properties of derived elastomers. B. E. CONWAY, *J. Polym. Sci.*, 1960, 46, 129–138. Department of Chemistry, University of Ottawa, Ottawa, Canada. The stress-strain behaviour of three elastomers prepared from polyoxypropylene glycols has been examined. The data are used as a basis for the interpretation of swelling behaviour previously reported for the materials and the influence of the degree of cross linking is discussed.

318. Polymer solutions. Part 5. Viscosity of poly(methyl acrylate) in mixed solvent media. GUNDIAH, N. V. VISWANATHAN and S. L. KAPUR, *J. Sci. Ind. Res., India*, 1960, 19, B191–195.

319. How the chlorine content of epoxy resins affects physical properties. W. J. BELANGER and S. A. SCHULTE, *Modern Plastics*, 1959, 37(3), 154–159. Devco and Raynolds Inc., U.S.A.

320. Viscosity and molecular association. Part III. Association of phenols and amides. L. H. THOMAS, *J. Chem. Soc.*, 1960, 4906–4914. Department of Chemistry and Chemical Engineering, Glamorgan College of Technology, Treforest. For unassociated substances viscosity η specific volume v , and vapour pressure p are related by

$$\log_{10} \eta/v = b - a \log_{10} p$$

for associated liquids

$$\eta \sqrt{v} = A/p^{0.25} + D/pd$$

A, a, b, D, d are constants.

W.H.B.

321. The viscosity of concentrated polymer solutions. T. GILLESPIE, *J. Polym. Sci.*, 1960, 46, 383–393. Physical Research Laboratory, The Dow Chemical Co., Midland, Michigan, U.S.A. A theory is developed which predicts departures from Newtonian flow in concentrated polymer solutions, these departures being proportional to either the first or second powers of the stress according to the particular system investigated. The theory is thus more able to explain experimental observations than existing treatments which predict only a square law. The application of the theory to an actual system is outlined and the role of molecular entanglements is discussed.

Section E

PASTES AND SUSPENSIONS

322. Pressures on objects embedded in rigid cross-linked polymers. G. H. DEWEY and J. O. OUTWATER, *Mod. Plastics*, 1960, 37(6), 142. Department of Mechanical Engineering, University of Vermont, Burlington, Vt. The experimental value of the pressure between an object embedded in a fully cured resin corresponds well with the theoretical value on the basis that the pressure is solely due to differential thermal expansion.

323. Heat transfer to non-Newtonian fluids under laminar flow conditions. A. B. METZNER and D. F. GLUCK, *Trans. Soc. Rheol.*, 1960, 4, 364-365. University of Delaware, Newark, Delaware. Heat transfer behaviour has been studied experimentally and theoretically for the case where viscous heat generation may be neglected. Up to 37 per cent of the total heat is transferred by natural convection even in highly non-Newtonian systems.

324. Small plastic deformations in the strain-hardened region of dispersed ground. G. M. LOMIZE, *Dokl. Akad. Nauk*, 1960, 130, 150.

325. Scientific foundation for the preparation of colloid-graphite lubricants. L. A. FEIGIN and I. B. DAVIDOVSKAYA, *Dokl. Akad. Nauk*, 1959, 128, 1012.

326. Rheologic properties of colloidal petroleum solutions. K. F. ZHIGACH, N. M. KASIANOV and L. K. MUKHIN, *Dokl. Akad. Nauk*, 1960, 130, 589.

327. On the role played by the rate of sedimentation in the accumulation of absolute masses of organic matter in the precipitate. L. A. NAZARKIN, *Dokl. Akad. Nauk*, 1960, 130, 868.

328. The appearance of thixotropic structure in an OT aerosol-sucrose solution and in two-sided films formed from it, and the effect of this structure on the stability of foams. A. A. TRAPEZNIKOV and V. F. TIKAVYI, *Dokl. Akad. Nauk*, 1959, 128, 337.

329. Estimation of the effects of surface-active lubricants on the friction deformation of surfaces. V. D. EVDOKIMOV and A. S. RADCHIK, *Dokl. Akad. Nauk*, 1959, 128, 713.

330. Rheologically acceptable waxes from wool grease. A. H. MILBURN and E. V. TRUTER, *J. Appl. Chem.*, 1960, 10, 226-228. Textile Chemistry Laboratory, University of Leeds. Rheological properties of ethylenediamides and hexamethylenediamides of suitably refined woolgrease acids are superior to those of beeswax.

331. An experimental investigation of the unsteady flow of viscous plastic fluids. G. D. ROSENBERG, *Dokl. Akad. Nauk*, 1959, 129, 56.

SECTION E

332. The effects of the ripening and ageing of aluminium naphthenate gels on their elastic deformation, shear strength, relaxation time and structure. A. A. TRAPEZNIKOV, *Dokl. Akad. Nauk*, 1959, **129**, 387.

333. Normal and shear stresses as dependent on the value of strain when aluminium naphthenate gel passes from a state of rest to steady flow. A. A. TRAPEZNIKOV *et al.*, *Dokl. Akad. Nauk*, 1960, **133**, 637.

334. Radial particle displacements in Poiseuille flow of suspensions. G. SEGRÉ and A. SILBERBERG, *Nature, Lond.*, 1961, **189**, 209-210. Weizmann Institute of Science, Rehovot, Israel. Macroscopic spherical particles collect into a thin annular region when an initially uniform dilute suspension is passed in laminar flow through a straight tube. The development of the effect is proportional to the length of the tube, to the mean velocity of flow and to the fourth power of the ratio of particle radius to tube radius. Various aspects of this effect are discussed. W.G.C.

335. Weissenberg effect in the thick white of the hen's egg. H. G. MULLER, *Nature, Lond.*, 1961, **189**, 213-214. Spillers, Ltd., Technological Research Station, Station Road, Cambridge.

336. Rheology in search of structures. II. A. VOET and W. N. WHITTEN, *Trans. Soc. Rheol.*, 1960, **4**, 363-368. J. M. Huber Corp., Borger, Texas. Twelve dispersions of carbon black in white mineral oil were studied, viscometrically and conductimetrically. Yield values show poor correlation with structure, but oil absorption and specific plastic viscosity show somewhat better correlation.

337. The dependence of the ultimate high-elastic and rupture deformation on the rate of deformation of an Al. naphthenate gel-sol. T. G. SHALOPALKINA and A. A. TRAPEZNIKOV, *Kolloidnyĭ Zh.*, 1960, **22**, 735. Inst. of Phys. Chem., Acad. Scis., Moscow. An investigation has been undertaken of the relation between the high elastic deformation ϵ and shear stress P and the predetermined deformation ϵ in 2 per cent aluminium naphthenate gel in vaseline oil over the range of deformation velocities 0.46 to 1112 sec⁻¹. Measurements were made in an elastoviscometer and elastorelaxometer, based on the coaxial cylinder principle. The data obtained showed that the value of the maximum high elastic deformation ϵ_{max} and of the predetermined deformation corresponding to them ϵ_m pass through a maximum with rise in ϵ . At the same time a continuous fall takes place in the value of the deformation ϵ_r corresponding to maximum strength of the structure P_r . The latter, as well as the fall in ϵ_{max} in the range of high ϵ (is explained by the difficulty of the unfolding of chainlike aluminium naphthenate particles in the gel and their premature rupture. New data have been obtained indicating that the velocity of the thixotropic formation of structure determining high elastic deformation increases with increasing deformation velocities. Data have been obtained on the change in the shear modulus over various ranges of elastic deformations at various deformation rates. [Russian, English abstract]

Author (abridged abstract)

338. Some viscous and elastic properties of rubberised bitumens. L. M. SMITH, *J. Appl. Chem.*, 1960, 10, 296-305. British Rubber Producers Research Association, Welwyn Garden City. The simultaneous changes in the viscous, elastic and brittle properties resulting from the addition of rubber to bitumen have been investigated for several types of rubber, and bitumens ranging in hardness from 170 penetration to 55 penetration. Changes in viscosity and low temperature extensibility are due, in the main, to the molecular (or near molecular) dispersion of rubber in the bitumen. For a given bitumen these changes are linearly related both to each other and to changes in softening point, thus giving a simple method of assessing the relative merits of different types of rubber. Sulphur, added to latex or present in a vulcanised rubber causes a rapid breakdown of the rubber when heated with bitumen. An equi-viscous basis is suggested for the characterisation of rubberised bitumens. Author

339. Effect of coal and long chain polymers on the characterisation of bituminous road binders. H. KARIUS and E. J. DICKINSON, *J. Appl. Chem.*, 1959, 9, 542-552. National Institute for Road Research, Pretoria, South Africa. Both additives produce an improvement in the viscosity temperature characteristics of bitumens and a reduction in low temperature brittleness. If both coal and polymer are incorporated together, the improvement is greater than the sum of the separate effects. An apparatus is described for assessing brittleness under stresses and loading times of the same order as those occurring in traffic. Author

340. The effect of enzymic preparations from molds on the elastic-resilient-viscous properties of hydrated protein and starch structures. B. A. NIKOLAEV, S. S. SHKADINA, *Dokl. Akad. Nauk*, 1960, 133, 893.

341. Stability of water oil contact in stratified porous media. V. G. OGANDZANIANTS, *Dokl. Akad. Nauk*, 1960, 134, 59.

342. Certain features in the emulsification of structured liquids. L. J. KREMNEV and L. A. BORODINA, *Dokl. Akad. Nauk*, 1960, 131, 438.

343. The structural viscosity of the water solutions of carboxymethyl-cellulose. K. F. ZHIGACH, M. Z. FINKEL'STEIN and I. M. TIMOKHIN, *Dokl. Akad. Nauk*, 1959, 126, 1025.

344. The rheology of letterpress and offset inks. E. A. APPS, *Research*, 1960, 13, 212-217. Wynne and Selby Ltd., London. The relation between empirical flow curves, observed ink film behaviour and theoretical prediction is discussed. The large effect of water content is explored in detail.

345. The influence of the rheological properties of printer's ink on its behaviour in the process of printing. T. I. GUDKOVA, L. A. KOZAROV-KITSKII and N. V. MIKHAILOV, *Dokl. Akad. Nauk*, 1960, 131, 890.

346. Automatic ink control for rotogravure. G. S. ALLEN, *Paint Manufr.*, 1961, 31, 2. Report of a lecture arranged by the Technical Training Board of the Printing Ink and Roller Making Industry. An automatic ink control system (Idotron) for a colour rotogravure press was described.

SECTION E

In this, viscosity is controlled through the drag on a cup rotated by an electric motor and the automatic operation of a solvent valve.

347. Concerning the effect of the structural-mechanical properties of printing inks on their behaviour in the process of printing. T. I. GUDKOVA, L. A. KOZAROVITSKIĬ and N. V. MIKHAILOV, *Kolloidnyiĭ Z.*, 1960, **22**, 649. All-Union Institute for Scientific Research in the Printing Industry, Moscow. It is claimed that previous rheological measurements have been made at shear rates much lower than obtaining in practice ($\sim 10^4 \text{sec}^{-1}$) nor have changes caused by rise in temperature generally been allowed for. The minimal viscosity of the broken-down structure is said to correlate well with quality for printing. [Russian, English abstract]

G.W.S.B.

Section F

LIQUIDS

348. Steady flow of viscous fluid. I. I. VOROVICH and V. I. IUDOVICH, *Dokl. Akad. Nauk*, 1959, **124**, 542.

349. Steady motion of a viscous incompressible fluid in a pipe. O. A. LADYZHENSKAIA, *Dokl. Akad. Nauk*, 1959, **124**, 551.

350. Viscosity-temperature properties of high-molecular hydrocarbons of a mixed structure. S. R. SERGIENKO, L. N. KVITKOVSKII and A. A. PETROV, *Dokl. Akad. Nauk*, 1959, **126**, 798.

351. Dynamic balance in the deep current field of the Pacific. V. A. BURKOV and M. N. KOSHLIAKOV, *Dokl. Akad. Nauk*, 1959, **127**, 70.

352. On the possibility of determining the position and speed of discontinuous currents in the littoral zone of tideless seas. I. F. SHADRIN, *Dokl. Akad. Nauk*, 1959, **127**, 884.

353. The effects of surface-active lubricants on resistance to shear in friction. I. S. AVETISIAN and G. I. EPIFANOV, *Dokl. Akad. Nauk*, 1959, **128**, 973.

354. The behaviour of the antimonides of aluminium, gallium and indium in the liquid state. V. M. GLAZOV and A. A. VERTMAN, *Dokl. Akad. Nauk*, 1958, **123**, 492.

355. Viscosity of liquid nickel and its alloys with copper. A. A. VERTMAN and A. M. SAMARIN, *Dokl. Akad. Nauk*, 1960, **132**, 572.

356. Viscosity determinations in silicate melts. I. A. BULAVIN, *Dokl. Akad. Nauk*, 1960, **130**, 133.

357. The viscosity of some binary hydrocarbon mixtures and condensate gases in the supercritical region. S. L. ZAKS and V. I. SERGEEVICH, *Dokl. Akad. Nauk*, 1959, **129**, 1332.

LIQUIDS

358. Viscous properties of alkyl-aromatic hydrocarbons and their hydrogenated analogues. P. I. SANIN, AL. A. PETROV, S. R. SERGIENKO and E. A. NIKITSKAIA, *Dokl. Akad. Nauk*, 1960, **130**, 338.

359. Capillary rise of a liquid in porous media and capillary hysteresis. D. N. NEKRASOV and M. M. KUSAKOV, *Dokl. Akad. Nauk*, 1960, **133**, 1379.

360. Spontaneous thinning of tenuous bilateral liquid films. A. SHELUDKO, *Dokl. Akad. Nauk*, 1958, **123**, 1074.

361. Study of molar sound velocity in liquids. P. R. K. L. PADMINI, K. SUBBA RAO and B. RAMACHANDRA RAO, *Trans. Farad. Soc.*, 1960, **56**, 1404-1408. Ultrasonic Laboratory, Andhra University, Waltair, India. A study of a number of six- and five-membered ring compounds revealed positive contribution to molar sound velocity due to these ring structures. From a study of about ten liquids containing semipolar bonds, it is shown that this type of linkage contributes a negative value of -25 to the molar sound velocity. Molar sound velocity increments for several atoms and bonds for which the data are not available are reported. W.H.B.

362. The effect of temperature on the viscosity of sucrose acetate isobutyrate. ANON, *British Plastics*, 1960, **33**, 73. Eastman Chemical Products, U.S.A. The material has a very high viscosity index, aiding processability.

363. The calculation of viscosities of binary systems. L. J. BARANYAI, *J. Oil. Col. Chem. Ass.*, 1960, **43**, 787-800. 29 Campbell Avenue, Normanhurst, New South Wales, Australia. The method of calculating the viscosity of solutions of polymers from empirically determined constants (*J. Oil. Col. Chem., Ass.* 1960, **43**, 214) is now applied to binary systems of solvents. W.H.B.

364. Excess ultrasonic absorption in diethylamine-water mixtures. R. N. BARFIELD and W. G. SCHNEIDER*, *J. Chem. Phys.*, 1959, **31**, 488-494. *Pure Chemistry Division, National Research Council, Ottawa, Canada. Ultrasonic velocity and absorption coefficient, density and shear viscosity were measured as a function of composition and temperature. Maxima were found in viscosity and sound velocity and particularly in ultrasonic absorption at 10 mole per cent diethylamine. A compressional relaxation mechanism in which the ratio of hydrogen bands between like and unlike molecules alters during the compression cycle is used to explain the results.

365. Viscosity measurements in liquid helium. II. C. B. BENSON and A. C. HOLLIS HALLETT, *Canad. J. Phys.*, 1960, **38**, 1376-1389. University of Toronto, Toronto, Canada. An oscillating sphere was used, allowance being made for the viscous drag of the gas surrounding the rod which connected the sphere to the torsion suspension fibre. The results agree with previous measurements using a rotating cylinder, but not with those obtained using an oscillating disc.

SECTION F

366. On the existence of vitreous oxygen. J. D. MACKENZIE, L. B. NESBITT and W. B. HILLIG, *J. Chem. Phys.*, 1959, **30**, 1102-1103 (letter). General Electric Research Laboratory Schenectady, N.Y. An observation by Wahl* is often quoted as indicating the existence of vitreous ("rigid glassy") oxygen at temperatures slightly above the melting point of the crystal. Later measurements of the viscosity of liquid oxygen in this temperature region render this doubtful. Experiments reported here suggest that the isotropic solid observed by Wahl is the cubic γ phase of solid oxygen. **Proc. Roy. Soc. (Lond.)* A88, **61** (1913).

Section G

GENERAL

367. On the plasticity of thyroid gland structure. A. A. WOITKEVICH, *Dokl. Akad. Nauk*, 1959, **128**, 1094.

368. The relation between the volume of blood pumped within a minute and the resistance of the peripheral vessels in man. E. E. BABSKY, V. L. KARPMAN and M. A. ABRIKOSOVA, *Dokl. Akad. Nauk*, 1960, **130**, 465.

369. Initial pressure dependence of thermal conductivity and viscosity. D. E. STOGRYN and J. O. HIRSCHFELDER, *J. Chem. Phys.*, 1959, **31**, 1545-1554. University of Wisconsin, U.S.A. The pressure coefficients for the thermal conductivity and viscosity of gases is calculated taking into account the effect of molecular association and collisional transfer.

370. Representation of the properties of working materials on log-log graphs. I. W. SCHMIDT, *Die Technik*, 1959, **14**, 458-463. The use of log-log graphs for plotting yield point or tensile strength against elongation is considered for several materials, and their application to the specification of materials properties is discussed.

371. Filtration of rarified air through porous bodies in the transition pressure region. N. V. TALAEV, *Kolloidnyi Zh.*, 1960, **22**, 702. Inst. of Phys. Chem., Acad. Scis., Moscow. An apparatus has been devised for investigating gaseous flow through highly porous bodies in the region of pseudomolecular flow. The curve depicting the flow as function of pressure exhibits a minimum, as it takes place in the flow of gases through capillaries. The minimum is expressed more sharply for higher porosity coefficients. The Deryagin formula for the specific surface area is to a rough approximation valid for highly porous bodies even in the pseudomolecular transition region where obviously molecular flow does not take place. [Russian, English abstract] Author

VOL.
4
1961

BOOK REVIEWS

Flow properties of blood and other biological studies. Proceedings of an informal discussion convened jointly by The Faraday Society (Colloid and Biophysics Committee) and The British Society of Rheology.

Edited by A. L. COPLEY and G. STAINSBY.

Pergamon Press, Oxford, 1960. 428 pp. 75s.

This volume contains the conclusions of recent experimental investigations, many *in vivo*, on the flow of blood and other body fluids, with full reference to earlier work and observations, and with a concise account of the discussions of 20 papers.

The frontispiece is a portrait of POISEUILLE whose pioneering work on blood flow established the well-known viscosity laws and who, in 1835, observed that red blood cells stream axially through the small blood vessels, there being a narrow cell-free plasma zone next to the walls. Considerable attention both in the papers and discussions has been devoted to this marginal zone and "wall effects" and their significance.

Prof. P. R. ALLISON of the Nuffield Department of Surgery, University of Oxford, in his opening address remarked that when he became interested in blood pumps much help was obtained from an engineer whose job was to pump raspberries along a tube without crushing them and his first knowledge of the rheology of the circulation was learnt not in a medical school but while fishing with a water works engineer the river banks having the advantage of being inelastic. This benefit of a biologist discussing common problems with an engineer is shown *par excellence* in the Volume where the result is given of the meeting together of biologists, physicists, chemists, engineers, mathematicians and other workers (40 contributions by 48 authors) to discuss the problem of blood circulation.

Such mutual assistance in biorheological problems must ultimately lead to advances in the diagnosis, treatment and prevention of disease.

The Volume, in five parts, is addressed to a wide scientific public including physiologists, haematologists, physicians and surgeons. The first lecture, Part I, indicated the impact of rheology on the general problem and defined various terms, stress components and stress ellipsoid, elastic recovery of liquid systems, flow birefringence, etc. There followed papers giving experimental data and conclusions using new techniques and specially designed apparatus. Attention is directed to these instruments in Part IV which is devoted to their descriptions and methods of use. Ingenuity has not been spared in their construction and development.

The exhibits included rheological models, the rheogoniometer, apparatus for measuring wall adherences, the strength of blood clots, the consistency of biological fluids and a device for the measurement of blood flow by electromagnetic induction. Equipment for studying flow birefringence, elastic flow and the rheological changes in blood and milk during coagulation was also described. In Part V is given the running commentary (34 pages and 10 figures) on eight recent films showing blood flow in veins, in the basilar artery, through Y-junctions and a micro-circulatory study of lymph, etc. Motion pictures through a microscope dealt with some categories of blood rheology illustrating a transition

from freely flowing blood to blood which suddenly "refuses" to circulate.

The highly important and complex problem of pulsatile blood flow in elastic vessels has been squarely faced in many of its aspects, especially in relation to Reynolds' turbulence at forks of arteries, to pressure effects in living microscopic vessels, to wall adherences, to the *sigma* phenomenon and to the presence of anti-coagulants and haemolysis of erythrocytes. An excellent beginning to the formulation and understanding of the formidable problem of the movement of body fluids has been made and there has been a thoughtful and patient analysis of observations so far made, with a frank admission when no conclusions could be reached. Empiricism is out. Further new investigations can well begin on the basis of this Volume which gives clearly the generally agreed facts and conclusions. The information available and the apparatus described in the Volume can well be used for teaching purposes.

The relation between the highly asymmetric and large molecular structure of body substances such as protein-hyaluronic acid complexes, mucoproteins, etc. and the flow properties of their colloidal dispersions has been studied by several authors. Similarly, the important link between the flow properties and sedimentation rates of erythrocytes in plasma has been shown. The suspension stability of blood has been studied from the early part of the century when it was found that the rate of sedimentation is increased in many pathological conditions, notably in acute infections, trauma and burns. The effect of the addition of hyaluronic acid complexes and other highly asymmetric large molecules on sedimentation rates has been determined.

Any increased association of dispersed particles usually results in increased sedimentation rates, decreased flow rates and more pronounced rheological properties. In normal blood there is an attraction between the dispersed particles and these forces permit the cells during blood circulation to move freely within the central axial core preventing them from entering the clear marginal zone. When the flow stops, the cells apparently fill the blood vessels completely but it is yet not understood why a cell appears to move faster than the plasma transporting it. A large proportion of the Volume is devoted to methods of measuring the time dependent sol to gel transition in coagulation and agglutination and in measuring the rheological consistency of the clots; numerous curves are shown relating loading and movement, stretch deformation and recovery, and data on elastic memory, thixotropy, and relaxation are given. These investigations were undertaken mainly from the standpoint of thrombus (intravascular clotting during life). The special techniques and instruments used include the thrombelastograph, "T. E. Graph", the micro U-tube gelometer, glass plates separating at a steady rate for measuring the viscosity consistency and *spinnbarkeit* of human cervical mucus and its dependence on hormonal factors, a falling plunger "consistometer" for measuring yield values, a light pendulum for measuring the tensile strength of blood clots and other *ad hoc* devices. The variety of results obtained with the different instruments and techniques indicates the remarkably versatile response of body substances to deformation according to the circumstance. Thus, it was indicated that the high extensibility of resting muscle depends on the presence of adenosine triphosphate and great changes in extensibility occur as the muscle passes into rigor attributable to the destruction of ATP which besides being the

VOL.
4
1961

energy source of contraction itself serves also to keep the chains of the contractile protein, actomyosin, dissociated in the form of separate chains of actin and of myosin which can slip past one another when a load is applied to the muscle. Although our knowledge on blood circulation began with HARVEY's discovery in 1616, yet this knowledge brought up-to-date touches only the fringes of this unknown world of movement; the science of rheology has been exceptionally helpful in bringing together observations from various scientific sources and co-ordinating them. But it is not easy to explain why the nervousness of a cow will upset the normal behaviour of its blood in a U-tube gelometer or to give the reason why red blood cells divide when passing through a minute opening in a living capillary wall or alter size and shape and speed according to their environment, or why blood flow is different *in vitro* than *in vivo*.

The Volume is important if only it serves to draw attention to the complexity and importance of the problem of blood circulation and the vast territory yet to be explored so that the healing of mankind may be furthered.

E. W. J. MARDLES

Physical methods of investigating textiles.

Edited by R. MEREDITH and J. W. S. HEARLE. Textile Book Publishers. 1959. 885 pp.

Although one of the contributors to this volume has found a relevant reference of some antiquity (THOMAS YOUNG's determination of fibre diameters by diffraction of light), most of the techniques described have only been applied to the study of textile materials since about 1940. That is to say, the physics of textiles has been developed mainly since the discovery and commercial acceptance of the synthetic polymer fibres. This is not surprising. These fibres have attractive properties, such as high strength, low moisture regain, and good abrasion resistance, but they are expensive. To compete with the cheaper natural fibres they must be made in the most economical manner, and their disadvantages must be overcome. These lie mainly in subjective phenomena, like the "handle", "drape", crease resistance and porosity to body moisture of apparel fabrics. Moreover, one is less inclined to tolerate a fault in an expensive material. Some of the most important properties of the synthetics, then, are of a rheological nature. The actual manufacture of the fibres also involves the rheological behaviour of the material, at many stages. Three of the chapters of this book deal directly with the rheology of fibres.

The methods of manufacture of fibres are continually being developed to allow them to be "tailored" to suit particular applications. Success here depends upon knowing as much as possible about the structure of a fibre, upon knowing how to control the structure and on having well-defined tests for the final product. "Physical Methods of Investigating Textiles" provides a most useful summary of the techniques now available for studying the structure of fibres, yarns and fabrics, and for testing their mechanical and other physical properties. The book is based on

a course of lectures given at Manchester College of Technology in 1956-1957. It covers aspects of the subject which are likely to be tackled only by specialists as well as those which any textile technologist may meet at any time. It is marred only by the slovenly presentation of one of the chapters.

M. F. CULPIN

VOL.
4
1961

DL.
1
961

VOL.
4
1961

Section A

THEORETICAL

372. Theory of rolling friction for spheres. D. G. FLOM and A. M. BUECHE, *J. Appl. Phys.*, 1959, **30**, 1725. General Electric Research Laboratory, Schenectady, New York. A theory of rolling friction featuring the importance of elastic hysteresis losses is presented. A simple model of retarded elasticity is chosen to represent the physical properties of the material. A prediction resulting from the theory is that the coefficient of friction for a relatively hard sphere rolling on a softer base material should vary with speed so as to go through a maximum. This relationship resembles closely the variation of mechanical loss with frequency. The results are not restricted to rolling but also apply to well-lubricated sliding where shearing forcing have been minimized. Although the theory is developed for a material with idealized physical properties, it nevertheless affords a basis for comparing real materials and for predicting their frictional properties in cases where deformation losses are predominant. AUTHOR.

373. The viscosity of polydisperse emulsions. E. S. RAJAGOPAL, *Rheologica Acta*, 1961, **1**, 581-584. Dept. of Physics, Indian Institute of Science, Bangalore. Oldroyd's equation for the viscosity of a monodisperse suspension of liquid spherical droplets (with a finite amount of surface slip) is combined with a certain size distribution to give the viscosity for a polydisperse suspension on the assumption that the simplest averaging procedure is valid. The results are used to interpret certain small observed dependencies of suspension viscosity on particle size distribution (at constant volume concentration).

374. On the stress-strain relation for non-homogeneous isotropic elastic solids. R. STOJANOVITCH, *Archiwum Mechaniki Stosowanej*, 1960, **12**, 281. The stress-strain relations as well as the corresponding modified Lamé equations are derived. P.F.

375. On complete solutions for frictionless extrusion in plane strain. J. M. ALEXANDER, *Quart. Appl. Maths.*, 1961, **19**, 31-37. Dept. of Mechanical Engineering, Imperial College. Consideration is given to the extension of partial slip line field upper bound solutions to give the true yield point load when the material is constrained. In particular, the problem of frictionless extrusion is studied and it is shown that it is possible to extend only one of three available partial solutions. If it is not possible to extend the available partial solution, the use of discontinuous stress fields leads to lower bound solutions, and examples of this technique are given. AUTHOR.

376. On the theory of plastic potential. H. ZIEGLER, *Quart. Appl. Maths.*, 1961, **19**, 39-44. Zürich.

377. Theory of creep limited by self-diffusion. R. W. CHRISTY, *J. Appl. Phys.*, 1959, **30**, 760. Dartmouth College, Hanover, New Hampshire. A theory of steady-state creep at high temperature and stress is based on the climb of dislocations limited by the diffusion of vacancies from them.

SECTION A

The creep rate is found to be approximately $(MnL^2)D_0 \exp[-(W+E+U-\Delta W)/kT]$, where M is the number of dislocation sources per unit volume, n is the number of dislocations of length L per unit area, and $D_0 \exp(-W/kT)$ is the coefficient of self-diffusion. The number of jogs in the dislocations is determined by U , and E is an activation energy for formation of vacancies, due to relaxation of the lattice. The reduction in vacancy formation energy near a dislocation ΔW is estimated from the interaction energy of the climbing dislocations. A comparison of experimental data for Zn and $AgBr$ suggests that E is a significant contribution to the activation energy for ionic crystals but not for metals. The predicted increase in vacancy concentration during creep is too small to give observable effects. It is concluded that any observed enhancement of diffusivity during creep is due to increased mobility of defects.

AUTHOR.

378. Theory of oscillation of viscoelastic medium between parallel planes. GEORGE B. THURSTON, *J. Appl. Phys.*, 1959, **30**, 1855. The University of Michigan, Ann Arbor, Michigan. A theoretical description of sinusoidal oscillation of an incompressible viscoelastic medium between fixed infinite parallel planes is presented. The mechanical properties of the viscoelastic medium under sinusoidal shear are expressed by a complex viscosity coefficient. The general equation for oscillatory motion of an incompressible viscoelastic medium is developed. The solution to this equation is obtained for rectilinear motion parallel to a pair of infinite planes. The equation for velocity distribution between the planes is developed and several typical profiles are presented graphically. The equation for the acoustic impedance per unit area of plane is obtained. Functions from which the acoustic resistance and acoustic reactance may be determined are presented in graphical form for media which range from a perfect viscous fluid to a perfect elastic solid. The applicability of the theoretical results to oscillatory flow in rectangular tubes is discussed.

AUTHOR.

379. A dynamic hard sphere model. D. TURNBULL and R. L. CORMIA, *J. Appl. Phys.*, 1960, **31**, 674. General Electric Research Laboratory, Schenectady, New York. A simple two-dimensional model, in which uniform hard spheres are made to move steadily and apparently nearly at random, is described. At low sphere density the model exhibits "gas-like" behaviour. As the density is increased the behaviour becomes more "liquid-like" and then "crystallization" occurs. Many dynamic atomic phenomena, believed to occur in the gas, liquid, or solid state, are illustrated by the model.

AUTHOR.

380. Reversible and irreversible flow of high molecular weight materials. W. HOLZMULLER, *Rheologica Acta*, 1961, **1**, 495-505. Leipzig University, Germany. The linear phenomenological theory of viscoelastic materials is shown to be in agreement with the Eyring theory of viscous flow when certain hyperbolic functions in the latter are approximated by the first terms in suitable expansions. [German]

THEORETICAL

381. The hydrodynamics of materials whose rheological properties are complicated. J. G. OLDROYD, *Rheologica Acta*, 1961, 1, 337-344. University College of Swansea. The author's 8-constant set of equations relating stress and rate-of-strain tensors and their first order convected time derivatives is discussed as a possible description of viscoelastic liquids. The equations allow a description of shear rate dependence of viscosity, of the Weissenberg rod-climbing effect, and of the development of non-uniform pressures in a cone-and-plate apparatus.

382. Three main methods for the mathematical representation of after effects. M. MATSCHINSKI, *Rheologica Acta*, 1961, 1, 377-395. Centre National de la Recherche Scientifique, Paris. Limitations in the applicability of the Boltzmann-Volterra integral equations to hysteresis and other phenomena are discussed, and relations involving more general functionals are considered. [German]

383. Some considerations on the present state of macroscopic theories of rheological properties. F. SCHWARZL, *Rheologica Acta*, 1961, 1, 345-355. Centraal Laboratorium, Julianalaan 134, Delft, Holland. The form and properties of certain rheological equations of state are considered with special reference to infinitesimal strains in viscoelastic media, to finite strains in elastic solids, to non-linear viscous liquids, and to non-linear viscoelastic media. [German]

384. The stress tensor for visco-elastic bodies. H. GIESEKUS, *Rheologica Acta*, 1961, 1, 395-404. Farbenfabriken Bayer A.-G., Leverkusen, Germany. On the assumption that forces between molecules in a material are derivable from a scalar potential function of their separations, the author claims to show that the stress, when referred to a co-ordinate system convected with the material continuum, should be represented by a contravariant tensor density of second rank. [German]

385. Some remarks on the flow properties of elastico-viscous liquids in stationary shear flow. H. GIESEKUS, *Rheologica Acta*, 1961, 1, 404-413. Farbenfabriken Bayer A.-G., Leverkusen, Germany. Rheological equations in which the stress is expressed as an isotropic function of first and higher order time derivatives of strain are applied to calculate the pressure gradients which can be measured in the various types of rotational viscometers and in capillary flow, and from which differences in normal stress components can be deduced. [German]

386. Theory of the deformation and fracture of body-centred cubic transition metals. A. A. JOHNSON, *Nature, Lond.*, 1961, 189, 826-827. Metallurgy Dept., Imperial College of Science and Technology, London, S.W.7.

387. A theory of dilute suspensions. G. L. HAND, *Archive for Rational Mechanics and Analysis*, 1961, 7, 81-86. Dept. of Mechanics, The Johns Hopkins University, Baltimore. The results obtained by Jeffery for the motion of an ellipsoid suspended in a Newtonian fluid are used to formulate a theory of dilute suspensions. It is shown that the theory can be considered a specific case of Ericksen's theory of anisotropic fluids.

AUTHOR

SECTION A

388. Diffusion of small molecules. C. ROSSI and E. BIANCHI, *Nature, Lond.*, 1961, **189**, 822-824. Instituto di Chimica Industriale dell'Università, Genova. From measurements of the diffusion coefficients of a number of substances in two solvents, it is concluded that molecules smaller than solvent molecules diffuse slower the smaller they are, and that solute molecules larger than those of the solvent behave according to the Einstein-Stokes equation. W.G.C.

389. Internal pressure as the basis of a theory of solutions. C. V. SURYANARAYANA, *J. Sci. Industr. Res.*, 1961, **20A**, 141-144. Dept. of Chemistry, University of Mysore, Mysore, India. This review article concludes that the basis of viscosity and electrical conductance theory is the internal pressure, since if it can be theoretically explained that the variation of viscosity with internal pressure is exponential, it will follow that the electrical conductance falls exponentially with internal pressure. W.G.C.

390. Oscillatory flow in a fluid-filled elastic system. J. E. MALCOLM, *Nature, Lond.*, 1961, **190**, 88-89. British Medical Postgraduate School, Ducane Road, London, W.12. The pronounced tendency for a fluid-filled elastic tube to oscillate when the fluid is caused to flow by a small head of pressure is demonstrated. Use is made of an apparatus suggested by a new theory of the action of the heart. W.G.C.

391. Some aspects of the one-dimensional fluidized flow of divided solids. I. H. STOCKEL, *Rheologica Acta*, 1961, **1**, 415-422. St. Regis Paper Co., East Providence, R.I., U.S.A. For the case of steady, frictionless, vertical flow at constant area, the basic equations are formulated and used to derive a single first-order non-linear differential equation relating flow properties, voids, and gas pressure. Solutions of the equation obtained by two different methods are compared.

392. Stress analysis for linear visco-elastic materials. E. H. LEE, *Rheologica Acta*, 1961, **1**, 426-430. Brown University, Providence, R.I., U.S.A. The various mathematical forms of the stress/infinitesimal strain relations for isotropic materials are considered in relation to their convenience for solving given problems. For the problem of a rigid spherical indenter on a visco-elastic half-space, an integral operator form is more convenient than a differential operator form. The use of delta-functions in conjunction with the latter form can be advantageous (even where step-function stresses are involved) in cases where Laplace transform methods cannot be used.

393. On the foundations of 1-dimensional linear visco-elasticity. D. R. BLAND, *Rheologica Acta*, 1961, **1**, 422-426. Department of Mathematics, University of Manchester. Assuming that the microscopic structure of a material is mechanically equivalent to a network of springs and dashpots, the usual integral and differential forms of the stress-strain relations (for infinitesimal strains) are derived. In particular, it is shown that in the form $P\sigma = Q\epsilon$, (where P and Q are polynomials in d/dt , with constant coefficients; σ =stress; ϵ =strain), the zeros of P and Q are negative and alternate.

Section B

INSTRUMENTS AND TECHNIQUES

394. Cone-plate viscometer for operation up to 200°C. R. McKENNEL and K. WATKIN, *Rheologica Acta*, 1961, 1, 545-548. Ferranti Ltd., Moston, Manchester, 10. The lower plate of the Shirley-Ferranti cone-and-plate viscometer is heated by circulated oil.

395. Apparatus for measuring the viscosity of molten glass. W. WEBER and G. MEERLENDER, *Rheologica Acta*, 1961, 1, 538-544. Physikalisch-Technischen Bundesanstalt, Braunschweig, Germany. The torque acting on a platinum sphere which rotates in a ceramic cylindrical container having a hemispherical base is measured. Viscosities in the range 10^2 to 10^7 poise can be measured. [German]

396. Viscometry of very dilute protein solutions. P. MUNK, *Coll. Czech. Chem. Comm.*, 1960, 25, 2715-2719.

397. Flow of visco-elastic liquids from tubes. J. HARRIS, *Nature, Lond.*, 190, 993. Chemical Engineering Dept., University College of Swansea, Swansea. The thrust of a flowing liquid on a tube has been observed experimentally and compared with calculated values in relation to the flow-rate.
W.G.C.

398. The physical interaction of spherical particles in suspensions. V. FIDLERIS and R. L. WHITMORE, *Rheologica Acta*, 1961, 1, 573-580. Dept. of Mining and Fuels, University of Nottingham. A recently-developed apparatus is used to time the fall of a metallic sphere through a suspension of plastic spheres in various aqueous solutions of glycerine and metallic salts. A heterogeneous magnetic field formed by two coils wound in opposition was used to detect the position of the falling sphere. At constant volume concentration of the suspension and at small Reynolds numbers, the terminal velocity of the falling sphere is independent of the size of the suspended spheres. At higher Reynolds numbers the terminal velocity decreases as the size of the falling sphere approaches those of the suspended spheres.

399. Flow patterns in particle beds. N. J. HASSETT, *Nature, Lond.*, 1961, 189, 997-998. Dept. of Chemical Engineering, College of Technology, Loughborough, Leics. A technique has been developed using dye injection for tracing the flow pattern of water passing through particle beds. The technique was found to be useful in the pre-expansion stage, but the reverse during bed expansion. The visual observation of particle bed activation by air has also been studied. In all cases of water fluidisation, the expansion from fixed bed to particulate fluidisation passed through a stage closely resembling the gentle bubbling stage in air fluidisation. This is discussed.
W.G.C.

400. On determining the yield value of thick disperse systems. A. FINCKE and W. HEINZ, *Rheologica Acta*, 1961, 1, 530-538. Laboratorium

SECTION B

des Fachverbandes der Süßwarenindustrie, Cologne, Germany. Corrugations are introduced on to the surfaces of a concentric cylinder viscometer to avoid slip. Effects of these corrugations on the torque-curves for chocolate and other materials are shown. [German]

401. Rheology of adhesives, Parts VI, VII. Part VI : D. NARAYANAMURTI and R. C. GUPTA ; Part VII : D. NARAYANAMURTI, C. P. DHAMANAY and R. C. GUPTA, *Rheologica Acta*, 1961, **1**, 514-516, 516-519. Forest Research Institute, Dehra Dun, India. A Couette viscometer and a penetration viscometer are used to study the variation of viscosity with time for certain cashew nut shell oil adhesives.

402. Remarks on the interpretation of damping loops.—II. G. KEMMNITZ, H. NEUMANN and G. ESPANION, *Rheologica Acta*, 1961, **1**, 560-565. Farbenfabriken Bayer, A.G., Leverkusen, Germany. Quick methods for determining the energy loss per cycle from given hysteresis loops are considered for linear and non-linear materials. [German]

403. A new apparatus for the measurement of hysteresis loops of fibre-forming textile materials and their interpretation. W. HOFFMANN, *Rheologica Acta*, 1961, **1**, 549-560. Farbenfabriken Bayer A.-G., Leverkusen, Germany. The load-extension relations for a viscoelastic filament are interpreted mathematically in terms of 3- and 5-parameter spring and dashpot models. The analysis is applied to data obtained from perlon filaments using a recently-developed apparatus which exhibits the load-extension relations in the form of hysteresis loops on an oscilloscope. Departures from the elliptical form for these loops are attributed to non-linear material properties. [German]

404. Stress-optical analysis of fluids. W. PHILIPPOFF, *Rheologica Acta*, 1961, **1**, 371-375. Franklin Institute, Philadelphia, Penna., U.S.A. Measurements of the magnitude, Δn , and extinction angle, χ , of flow birefringence are made on several concentrated polymer solutions and compared with measurements of shear stress, τ , and of the angle χ_m , between the major axis of the stress ellipsoid and the lines of shear flow. χ_m is derived from values of total thrust in a cone-and-plate viscometer (a Weissenberg Rheogonometer). For a solution of a silicone in toluene, χ and χ_m are equal. For silicone, rubber, polystyrene and polyisobutylene solutions, Δn is proportional to $\tau \operatorname{cosec} 2\chi$. For a rubber solution and a nitrocellulose solution, $\chi = \chi_m = \frac{1}{2} \cot^{-1} (s/2)$, where s is the magnitude of "recoverable shear" measured from the recoil in a concentric cylinder apparatus. For a polyisobutylene solution, flow data are given for capillary tubes of different length-to-radius ratios.

405. Electrolytic tank for studying the flow of liquids through tubes of various cross-sections. M. J. DENTON and S. G. LIPSON, *J. Sci. Instrum.*, 1961, **38**, 150-152. The British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester. Analogue methods of solving the Poisson equation in two dimensions are discussed briefly. The electrolytic tank equivalent must have a uniform current source density ; an approximation to this is achieved by introducing equal currents through

VOL.
4
1961

INSTRUMENTS AND TECHNIQUES

conductors spaced in a square lattice. As examples, the flow velocity distribution in a tube of rhombic cross-section is shown, and the equivalent radii for rhombic tubes of various angles are found. AUTHOR

406. New methods of measuring mechanical quantities in rheology. K. HOTTINGER, *Rheologica Acta*, 1961, 1, 525-530. Darmstadt, Pallaswiesenstr. 172, Germany. The advantage of using resistance strip strain gauges and movable core inductances in certain rheological apparatus are discussed. [German]

407. On relaxation spectra in hard polymers. B. ALBRECHT and A. M. FREUDENTHAL, *Rheologica Acta*, 1961, 1, 431-445. Columbia University, New York. Relaxation spectra for a fabric-filled and a cord-filled phenolic polymer are computed from torque and twist data obtained from tubular samples at -70°F , 72°F and 200°F .

408. Heating effects on deformation. Investigations with rubber. W. DICK, A. D. ENGELTER and F. H. MÜLLER, *Rheologica Acta*, 1961, 1, 506-510. University of Marburg/Lahn, Germany. A new apparatus for measuring heat flow during elongation and retraction of polymer solids has shown that the internal energy of rubber changes in simple elongation at constant pressure. [German]

409. Transmission electron microscopy studies of the mechanism of plastic deformation. AUREL BERGHEZAN and ANGELINE FOURDEUX, *J. Appl. Phys.*, 1959, 30, 1913. European Research Associates, S.A. Brussels, Belgium. Observation of the deformation of thin aluminium specimens inside the transmission electron microscope has revealed the intimate connection between deformation and the nucleation and motion of dislocations. Nucleation, slip propagation, and the process of deformation to the point of rupture have been observed visually on the fluorescent screen and photographed by both "still" and motion picture techniques. In this way even the detailed predictions of the dislocation theory of deformation have been confirmed, and the new phenomena of grain boundaries acting as "donors" or "acceptors" of dislocations have been discovered. AUTHOR

410. Stress waves and fracture surfaces. E. H. ANDREWS, *J. Appl. Phys.*, 1959, 30, 740. The British Rubber Producers' Research Association, Welwyn Garden City, Hertfordshire, England. Surface markings observed in the brittle fracture of certain frozen rubbers display striking wave-like characteristics. They have been identified as "Wallner" lines, caused by the interaction of the fracture front with stress waves emanating from the region of the fracture front itself. These oscillations are possibly caused by the supply of excess energy to the fracture tip. A value of approximately 1 : 2 is obtained for the ratio of fracture velocity to wave velocity. AUTHOR

411. Systematics of dynamic testing of high polymer rigid bodies. F. WINKLER, *Rheologica Acta*, 1961, 1, 676-689. Institut für Faserstoff Forschung, Teltow-Seehof, Berlin. The various possible types of experiment are listed. [German]

SECTION B

412. The flow properties of disperse-plastic masses in a roller gap, investigated for the case of whiting-water systems. R. RAUTENBACH, *Rheologica Acta*, 1961, **1**, 653-656. Technische Hochschule, Aachen, Germany. The pressure on a membrane in the surface of the rotating roller and the tangential force on a nearby plane plate are measured. Data are subjected to dimensional analysis in terms of gap size, roller radius and speed of rotation. [German]

413. Plastometry of heterogeneous materials. J. HOMAYR, *Rheologica Acta*, 1961, **1**, 593-598. Institut für Ziegelforschung, Essen-Kray, Germany. A parallel plate plastometer for the axial compression of cylindrical samples of brick-making raw materials is described. Flow curves are given for clay samples ranging from very plastic to very "short". [German]

414. Transistorised bloom gelometer. R. E. SCHACHAT and A. NACCI, *Food Tech.*, 1960, **14**, 117-118. Research Laboratories, General Food Corporation, Tarrytown, N.Y. A transistorised modification to the standard "Bloom Gelometer" is described.

415. Flow rates using nuclear or electron paramagnetic resonance techniques with applications to biological and chemical processes. J. R. SINGER, *J. Appl. Phys.*, 1960, **31**, 125. University of California, Berkeley, California. The equations for measuring flow rates are derived using NMR and EPR relaxation time determinations. Several experimental procedures are discussed. One method of measurement depends upon the difference between static relaxation times and the apparent relaxation time of materials flowing through the observation region. Another procedure utilizes saturated or inverted spins as a "tracer" to measure flow rates. These schemes may readily be applied to blood flow velocity measurements in humans or animals, or to mineral and chemical flow rate determinations. The Advantage of this spin resonance flowmeter is that the flow channel is not disturbed. Thus blood flow velocities are readily measured without the necessity of breaking the skin. AUTHOR

416. A recording flowmeter using a radioactive float. D. W. TIMS, *J. Sci. Instrum.*, 1961, **38**, 145-149. Warren Spring Laboratory, Stevenage, Herts. An instrument of the type comprising a float in a vertical tapered tube is often suitable for measuring low rates of fluid flow, but difficulties arise in obtaining remote indication, recording or control owing to the small physical size of the float and the consequent failure of conventional methods of detecting its position. This paper describes a method in which a radioactivated float and low-voltage, high-current Geiger tubes have been used to overcome these difficulties. AUTHOR.

Section C

METALS AND OTHER SOLIDS

417. Creep of metals under simple shear. E. N. DA C. ANDRADE and K. H. JOLLIFFE, *Nature, Lond.*, 1961, **190**, 431-432. Metallurgy Dept., Imperial College of Science and Technology, London, S.W.7. At low

VOL.
4
1961

strain, it has been found with leads containing differing small amounts of foreign metal and with cadmium that the strain under simple shear stress varied as $t^{\frac{1}{2}}$. This law applied in the range of strain 0.012 to 0.035. Above this range, the strain varies as $t^{\frac{1}{3}}$. Below a strain of 0.012, it is suggested that a power law of $t^{\frac{1}{2}}$ is valid. W.G.C.

418. Creep of metals and computations for creep design. YU. N. RABOTNOV, *Rozprawy Inzynierskie*, 1960, 8, 349. Warsaw, Author: Hydrodynamic Institute, Novosibirsk, USSR. Various creep theories are surveyed, and their application to design problems is considered in the light of experimental data relating to creep failure in practice, e.g. turbine discs. [Polish] P.F.

419. Thermal shock behaviour of brittle materials. M. L. LEVIN, *Nature, Lond.*, 1961, 190, 521-522. Hawker Siddeley Nuclear Power Co., Ltd., Sutton Lane, Langley, near Slough.

420. The flow stress of metals at low temperatures. P. FELTHAM, *Phil. Mag.*, 1961, 6, 209.

421. Cleavage fracture initiation in notched impact tests of mild steel. J. W. DAVIES and A. A. WELLS, *Nature, Lond.*, 1961, 190, 432. British Welding Research Association, Abington Hall, Cambridge.

422. Delayed lowering of the apparent elastic limit of steels after a depression under a stress attaining this limit (at ordinary temperatures). F. CAMPUS and K. GAMSKE, *Rheologica Acta*, 1961, 1, 491-494. University of Liège, Belgium. [French]

423. Recovery of internal friction in aluminium after plastic deformation. IVAR HOLWECH, *J. Appl. Phys.*, 1960, 31, 928. Department of Physics, University of Oslo, Norway. The internal friction in polycrystalline, super purity, aluminium has been measured during and after creep under constant load by the ultrasonic pulse method. The increase of internal friction was found to be independent of frequency in the measured range (2.5 to 12 Mc). The room temperature recovery of internal friction after unloading could be described by the formula: $= C_1/(t + C_2)^{1/3}$. Typical values of the constants C_1 and C_2 are 10 sec and 0.6 respectively. The experimental results are discussed in terms of the Weertman-Salkovitz theory of low amplitude internal friction. AUTHOR

424. Creep and stress relaxation in alpha-brass at low temperatures. P. FELTHAM, *Phil. Mag.*, 1961, 6, 259.

425. Static fatigue in concrete. J. GLUCKLICH, *Rheologica Acta*, 1961, 1, 356-361. Israel Institute of Technology, Haifa. Creep behaviour of cement stone beams is studied and analysed in terms of a model including a Kelvin element in series. It is suggested that the observation that beams under certain loads take an appreciable time to break may be explained on the assumption that breaking occurs when the spring in the Kelvin element reaches a critical extension.

SECTION C

426. The ultimate strength of continuous prestressed concrete beams. S. KAUFMAN and J. MAMES, *Arch. Inz. Ladowej*, 1960, **6**, 397. Warsaw. A detailed analysis of the bearing capacity of simply supported beams is shown to reveal interesting practical points relating to its ultimate bending moment as function of the steel content, eccentricity and degree of pre-stressing. [Polish] P.F.

427. The slow deformation of concrete. A. BRANDT and K. THIEL, *Rozprawy Inzynierskie*, 1960, **8**, 463. Warsaw. Modern theories on the creep, swelling and shrinkage of concrete are critically surveyed. [Polish] P.F.

428. Structure and strength of concrete. W. LENKIEWICZ, *Archiwum Inzynierii Ladowej*, 1960, **6**, 539. Warsaw. An unambiguous description of the strength of concrete is shown to require at least three parameters. Experiments are described which show that by appropriate densification and ageing its structure, and hence its strength, may be subjected to control. [Polish] P.F.

429. Utilisation of Indian asbestos : II. Asbestos-cement systems containing chrysotile and tremolite asbestos. A. K. CHATTERJI and K. D. DHARIYAL, *J. Sci. Industr. Res.*, 1961, **20D**, 121-123. Central Building Research Institute, Roorkee, India. Asbestos-cement systems containing chrysotile and tremolite asbestos and portland cement have been studied. It is suggested that the low strength of sheets made with tremolite asbestos is due to weakness of the continuum (glassy phase or gel structure) and not because of the low tensile strength of the tremolite fibres. The weakness of the gel structure may be removed and the strength of sheets improved either by adding a material which can remove the calcium ions from the system before gel formation starts, or by improving the tensile strength of glassy phases, or by a combination of both. AUTHOR

430. High-temperature mechanical properties of graphite. I. Creep in compression. PAUL WAGNER and ALLEN R. DRIESNER, *J. Appl. Phys.*, 1959, **30**, 148. University of California, Los Alamos Laboratory, Los Alamos, New Mexico. Measurements have been made on the steady-state rates of compressive creep of graphite in the temperature range 2270-2780°K. Creep to failure was observed to occur in one of two ways ; three out of seventeen samples exhibited a third stage of creep before failure occurred, the remaining fourteen samples failed in a manner analogous to that observed for graphite in tension, that is fracture without the appearance of a third stage. All the latter type of creep data are correlated by a classical rate equation of the form :

$$\text{rate} = K(\sigma/\sigma_D)^n \cdot \exp(-E/RT).$$

AUTHOR

431. High-temperature properties of graphite. II. Creep in tension. PAUL WAGNER, ALLEN R. DRIESNER and LARRY HASKIN, *J. Appl. Phys.*, 1959, **30**, 152. University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico. Measurements have been made on the steady-state creep rates of graphite in tension in the temperature range 2270-3270°K. Molded, extruded, and uranium "loaded" graphites were used in the course of investigation. The general characteristics of creep and

VOL.
4
1961

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

graphite at high temperatures have been described in the literature and the results presented here covering the range of steady-state creep 10^{-7} to 10^{-4} cm/cm-sec are in accord with published results. In addition, the tensile steady-state creep data are correlated by a classical rate equation of the form, rate $= f(U) (\sigma/\sigma_B)^n \exp(-E/RT)$, where $f(U)$ is a function of the uranium concentration in the graphite. AUTHOR

432. Time-dependent tensile properties. Part II. Porosity of deformed glasses. BERNARD ROSEN, *J. Polym. Sci.*, 1960, **47**, 19-27. Central Laboratories, Westinghouse Electric Corp., Pittsburgh, Pennsylvania, U.S.A. The slow growth and recovery of tensile microfractures in films of organic glasses are shown to account for an apparent tensile creep-enhancement of the coefficient of penetrant diffusion. The progressive breakdown evidenced in this way should be an important factor in the mechanical behaviour of visco-elastic solids.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

433. Rolling friction of a hard cylinder over a viscoelastic material. W. D. MAY, E. L. MORRIS and D. ATACK, *J. Appl. Phys.*, 1959, **30**, 1713. Pulp and Paper Research of Canada, Montreal, Canada. The rolling friction of a hard cylinder over a viscoelastic material is worked out in terms of the bulk properties of the material. It is found that the rolling friction has a maximum at a velocity corresponding to the peak of the relaxation time distribution. Both the load required to maintain the cylinder at constant depth of indentation and the coefficient of friction are dependent on the velocity of rolling. The shape of the rolling friction versus velocity curve is a first approximation to the distribution curve of relaxation times, indicating that rolling friction measurements can be used to determine the distribution experimentally. AUTHOR.

434. Normal stress effect in polymer solutions. TADAO KOTAKA, MICHIO KURATA, and NIKIO TAMURA, *J. Appl. Phys.* 1959, **30**, 1705. Department of Industrial Chemistry, Kyoto University, Kyoto, Japan. Normal stress phenomena are studied in solutions of some typical high polymers, polystyrene, methyl-cellulose, and sodium-carboxymethyl-cellulose, with a parallel plate instrument. The principle of procedures for separate determination of normal stress components with the parallel plate instrument is briefly described. The normal stress measurements are performed in shearing rates ranging from about 1.0 to 100. The results obtained, together with the flow curves, are discussed in terms of the cross-elasticity theory and of some molecular basis. It is concluded that polystyrene solutions roughly obey "Hooke's law in shear", while solutions of cellulose derivatives are remarkably "non-Hookean in shear". AUTHOR

435. Rolling friction of polymeric materials. I. Elastomers. DONALD G. FLOM, *J. Appl. Phys.*, 1960, **31**, 306. General Electric Research Laboratory, Schenectady, New York. Coefficient of friction for the rolling

SECTION D

of steel balls on butyl, silicone and Neoprene elastomers have been measured in the temperature range of 25 to 100°C. For equivalent amounts of deformation rolling friction is directly proportional to dynamic mechanical losses measured by a rebound method. In addition, the coefficients of friction vary directly with (load) and inversely with (ball radius). These results are in agreement with a recent theoretical predictions. The high mechanical losses and rolling friction for the butyl elastomer at 25°C drop sharply on increasing the temperature to 100°C. For the silicone and the Neoprene the losses and the friction decrease only slightly with increase in temperature.

AUTHOR

436. Polymers and the theory of numbers : molecular weight distributions from rheological measurements. E. MENEFFEE and W. L. PETICOLAS, *Nature, Lond.*, 1961, **189**, 745. Western Regional Research Laboratory, U.S. Dept. of Agriculture, Albany, California, U.S.A. By a mathematical treatment of Rouse's equation for the real part of the complex viscosity of a polymer solution, it appears that an easy and rapid method of experimentally determining the molecular weight distribution of a polymer is possible.

W.G.C.

437. Relaxation in structurally similar high polymers. F. KRUM and F. H. MÜLLER, *Rheologica Acta*, 1961, **1**, 446-451. Philipps-University, Marburg/Lahn, Germany. Mechanical and dielectric loss as a function of temperature is discussed in regard to two pairs of polymers : polyethylene and teflon ; terylene and polycarbonate. Values of the ratio of freezing and melting temperatures are held to be characteristic of side-chain similarities. [German]

438. Viscometric investigations on high polymeric acids : acid polysaccharide from *Plantago ovata*. P. C. BANDYOPADHYAY, *J. Sci. Industr. Res.*, 1961, **20B**, 101-104. Dept. of Chemistry, University College of Science & Technology, Calcutta, India. From the measurement of intrinsic viscosity at different degrees of neutralisation of the aqueous solution of an acid polysaccharide isolated from *Plantago ovata*, it has been concluded that the effective root-mean-square radius of the polymer coil increases with increase in per cent neutralisation and then diminishes. This has been interpreted in terms of the folding chain theory of the Fuoss and Strauss polyelectrolyte molecule.

AUTHOR

439. Effect of polydispersity in polystyrene on stress relaxation. A. V. TOBOLSKY and K. MURAKAMI, *J. Polym. Sci.*, 1960, **47**, 55-64. Frick Chemical Laboratory, Princeton University Princeton, New Jersey, U.S.A. Stress relaxation master curves are presented for polystyrene samples of \bar{M}_w between 20,800 and 310,000 and having heterogeneity indices from 1.0 to 15.92. It is shown that, at 1150°C

$$\log \tau_m = -15.10 \times 3.4 \bar{M}_w$$

where τ_m is the maximum relaxation time in minutes. It is also found that the quantity $\tau_m E_m / \eta$ correlates with the heterogeneity index of the sample, E_m being the partial modulus and η the flow viscosity. It is concluded that weight average molecular weights and a measure of the heterogeneity index may both be derived from stress-relaxation studies.

VOL.
4
1961

440. Finite deformation and tensile strength of polystyrene and polyethylene solids. C. C. HSIAO, *J. Polym. Sci.*, 1960, **47**, 251-257. University of Minneapolis, Minnesota. For samples of amorphous polystyrene and partially crystalline polyethylene, the fracture strengths for different degrees of uniaxial flow deformation are determined and are found to agree fairly well with theoretical predictions. For hard polymers the effect of uniaxial deformation on the tensile breaking stress of a simplified model solid is discussed.

441. Dependence of the thermomechanical properties of polypropene on its structural composition. M. P. ZVEREV, V. S. KLIMENKOV and T. F. KOSTINA, *Vysokomol. Soedineniya*, 1960, **2**, 1620-1624.

442. On the short-and long-time mechanical properties of crystalline polyolefines-relaxation spectra of low pressure polyethylene and polypropylene. H. OBERST and L. BOHN, *Rheologica Acta*, 1961, **1**, 608-617. Farbwerke Hoechst A.-G., Frankfurt(M) Hoechst, Germany. Stress relaxation measurements are combined with oscillatory (bending wave) measurements to give relaxation spectra in the range 10^{-4} to 10^4 seconds, -92°C to 150°C . [German]

443. Visco-elastic properties of polyethylene oxide in the rubber-like state. T. P. YIN, S. E. LOVELL and J. D. FERRY, *J. Phys. Chem.*, 1961, **65**, 534. Department of Chemistry, University of Wisconsin, Madison, Wisconsin. The visco-elastic properties of a sample of polyethylene oxide, molecular weight 1.15×10^4 , have been studied in the rubber-like state above the melting point. The real and imaginary parts of the complex compliance were measured between 0.04 and 1000 cps. in the temperature range from $68-120^{\circ}$. The creep compliance was measured at 80 to 100° , including creep recovery at 100° . The method of reduced variables gave superposed curves for all data with shift factors which followed the Arrhenius equation with an activation energy of 11.7 K.Cal/mole . The creep was represented by the Andrade equation with an additional term for steady state flow from which the steady flow viscosity was calculated. The relaxation and retardation spectra comprised plateau and terminal zones. The average spacing between coupling and entanglement points was estimated in two ways to be about 200 chain atoms of normal magnitude. However, the extremely wide plateau of the relaxation spectrum indicates that the entanglements are unusually tight. Since the transition zone lies at shorter times than those covered in the present experiments, the logarithm of the monomeric friction coefficient at 100° must be less than -6.4 .

AUTHOR

444. Pressure dependence of the viscoelastic behaviour of polyisobutylene. HARKRISHAN SINGH and A. W. NOLLE, *J. Appl. Phys.*, 1959, **30**, 337. Department of Physics, The University of Texas, Austin 12, Texas. The absorption of 4 mc/sec ultrasonic waves in polyisobutylene is measured as a function of temperature, for various pressures. The extreme limits of these variables are 1 to 1400 atm. and -20°C to 80°C , respectively. Approximate measurements of propagation velocity are also obtained. Pulse reflection apparatus is used. A magnetically actuated

SECTION D

holder places the sample in the signal path or removes it. Pressure-volume data are obtained for polyisobutylene at 30°C by means of a capillary dilatometer fitted with electrical contacts, in which the sample is placed with mercury. The expected behaviour of viscoelastic relaxation times with temperature and pressure is computed by adapting a theory due to Bueche. With additional assumptions concerning the compressibility, the theory gives a shift of the constant-frequency absorption maximum of 0.025 C°/atm, in approximate agreement with experiment.

AUTHOR

445. Dynamic mechanical properties of polyurethane. I. Dependence on chemical constitution and thermal history. H. JACOBS and E. JENCKEL, *Makromol. Chemie*, 1961, **43**, 132-143. Technische Hochschule, Aachen, Germany. A torsional pendulum (1 cycle per second) is used to measure the loss factor and complex modulus of several polyurethanes from -180°C to near the melting point. As the length of the CH₂-chains between urethane groups is increased, the damping maxima occur at lower temperatures. Damping depends on thermal history. [German]

446. The creep properties of a rigid vinyl chloride-vinylidene chloride copolymer. D. R. REID, *Rheologica Acta*, 1961, **1**, 603-607. B. X. Plastics, Manningtree, Essex. Stress, strain, time data at 20°C, 40°C and 60°C are given for simple elongation up to elongations of 4 per cent. An empirical relation is given.

447. The effect of extension on the structure of filaments of 6.6-nylon. D. V. BADAMI, F. P. CHAPPEL, M. F. CULPIN, D. MADOC JONES, and T. C. TRANTER, *Rheologica Acta*, 1961, **1**, 639-647. British Nylon Spinners, Pontypool, Mon. X-ray photographs are taken of nylon filaments during stretching; principal (optical) refractive indices are measured after stretching. Some of the structural changes occurring during stretching are attributed to the large temperature rise, which was also measured. The increase in birefringence and (X-ray) orientation with increase of draw ratio is consistent with the Kuhn and Grün model, but there is also an increase in density which is not.

448. Graft-polymerisation of methyl methacrylate with natural rubber in emulsion. C. C. MENON, S. N. KHANNA and S. L. KAPUR, *J. Sci. Industr. Res.*, 1961, **20D**, 98-101. National Chemical Laboratory, Poona, India. The mechanism of graft-polymerisation of methyl methacrylate with natural rubber has been investigated with special reference to the influence of initiator and monomer concentrations on the grafting efficiency and the chain length of the homopolymer. The graft co-polymer vulcanisates show substantial improvement in tensile strength, shear strength and abrasion resistance compared to natural rubber vulcanisates.

AUTHOR

449. Estimation of dynamic modulus and dynamic yield stress for "Perspex". J. ROBERTS, *Nature, Lond.*, 1961, **190**, 799-800. Ministry of Aviation, E.R.D.E., Materials Research Laboratories, Waltham Abbey, Essex. It has been found that a steel ball dropped on to a thick flat plate

VOL.
4
1961

of Perspex produces an electrostatic charge over the contact area. This effect has been investigated with the view of developing a simple method for estimating the dynamic modulus and dynamic yield stress. AUTHOR

450. Physical and mechanical properties of polybutan-amide. H. SEKIGUCHI, *Bull. Soc. chim. France*, 1960, 1839-1843. [French]

451. Effect of elongation and temperature on the recovery and apparent glass transition behaviour of an experimental modacrylic fiber. GEORGE M. BRYANT, *Text. Res. J.*, 1961, 31, 399-409. Research Department, Union Carbide Chemical Company, South Charleston, West Virginia. The shape of the stress-strain curve of the modacrylic fiber is correlated in a definite manner with the stress-relaxation and recovery behaviour. At the yield point, where the stress-strain curve has minimum slope, the tensile recovery decreases most rapidly with increasing elongation and the rate of stress relaxation passes through a maximum. Above the normal (low-strain) glass transition temperature of the fiber (90°C) the stress-strain curve no longer has a yield point, and the recovery and stress relaxation behaviour become relatively independent of elongation. The tensile-and-work-recovery values show a definite minimum (permanent set shows a maximum) occurring at the glass transition temperature at low, 1 per cent, strain and shifting to lower temperatures with increasing elongation. This shifting of the minimum in the recovery-temperature curves is interpreted to indicate a lowering of the glass transition temperature with stretching. At temperatures of 25° and 60°C the yield strain approximates that elongation required to reduce the minimum in the recovery-temperature curves to that temperature. These results lead to a fundamental definition of the yield point as the strain level at which the glass transition temperature is lowered to the experimental temperature. A free volume increase accompanying the stretching is postulated as the underlying mechanism whereby the glass transition temperature is reached. The equations of Ferry (13, 14) indicate that a quite reasonable value of 0.35 for Poisson's ratio could lead to an increase in free volume sufficient to speed up the molecular response by a factor of 10^8 at the yield strain. AUTHOR

452. Dynamic mechanical properties of polymerized epoxy resins. D. E. KLINE, *J. Polym. Sci.*, 1960, 47, 237-249. HRB-Singer Research Laboratories, State College, Pennsylvania, U.S.A. The dynamic mechanical properties of polymerized epoxy resins were studied, as functions of cure time, filler content and irradiation dose, over the range 80-600°K. The mechanical loss exhibits several dispersion maxima though the dynamic modulus decreases monotonically everywhere except in the interval 480° to 550°K.

453. Adhesion of polymers. Part 7. Adhesion of carboxyl-containing copolymers to various substrates. S. S. VOYUTSKII, V. L. VAKULA, N. I. SMELAYA and I. A. TUTORSKII, *Vysokomol. Soedineniya*, 1960, 2, 1671-1677.

454. Structure of reinforced butadiene-nitrile rubber vulcanisates by the softening-elongation relation. V. A. SHVETSOV, A. S. NOVIKOV and A. P. PISARENKO, *Vysokomol. Soedineniya*, 1960, 2, 1608-1612.

SECTION D

455. The flow properties of perbuna latices. S. K. MUKHOPADHYAY and J. PAWLOWSKI, *Rheologica Acta*, 1961, **1**, 584-592. Farbenfabriken Bayer A.-G., Leverkusen, Germany. The viscosities of three aqueous perbuna latices of different particle size, measured in different capillary viscometers, are Newtonian for concentrations in the range of 0.5% to 25% and non-Newtonian in the range 25% to 47%. By assuming that the particles are enlarged by an adsorbed liquid layer, the data are correlated with certain literature data for natural latices. [German]

456. On the tension-temperature coefficient of natural rubber. A. CIFERRI, *Makromol. Chemie*, 1961, **43**, 152-155. Chemstrand Research Center, Inc., Durham, North Carolina, U.S.A. Gee's approximate method for deriving the coefficient at constant volume and length from the measured coefficient at constant pressure and extension ratio is held to be inadequate and an alternative method is stated. New data on rubber evaluated by the alternative method show that 15% of the tension must be attributed to an internal energy change (at constant volume). This implies that the average size of a free rubber molecule should increase with temperature.

457. The torsional properties of single wool fibers. Part II. M. FEUGHELMAN and T. W. MITCHELL, *Text. Res. J.*, 1961, **31**, pp. 455-459. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Ryde, N.S.W., Australia. Torque-twist and torsional relaxation tests on single wool fibers in water over the temperature range 70°C to 44°C show a rapid change with temperature. This change indicates that torsional properties are dependent upon a rate process mechanism. In a previous paper it was postulated that these properties can be explained in terms of a matrix in the wool fiber acting as a cross-linked polymer stabilized by a network of polar bonds. The drastic change in torsional properties of the wool fibers when the pH is changed from 6.5 to 1.0 indicated that some of the bonds are salt-linkages; others will be hydrogen bonds. However, it is pointed out on the basis of the proposed model, that whereas the hydrogen bonds in the network can break and remake during mechanical deformation of the fiber, the salt-linkages on breaking apparently do not remake. AUTHOR

458. A new type of phenomenon of flow birefringence in macromolecular solutions. S. FUJISHIGE, *Nature, Lond.*, 1961, **189**, 653. Textile Research Institute, 4 Sawatari, Kanagawa, Yokohama, Japan. An investigation of solution states of methyl cellulose in aqueous systems showed that the observed optical anisotropy, as a function of the velocity gradient, changed anomalously. A tentative explanation is put forward. W.G.C.

459. Variation of elasticity along single microfibrils of bacterial cellulose. J. R. COLVIN, *Nature, Lond.*, 1961, **189**, 1029-1030. Division of Applied Biology, National Research Council, Ottawa 2, Canada. Random variations in tensile strength of microfibrils of bacterial cellulose have been observed under the electron microscope. The strains involved are believed to be caused by differential heating of the shadowed and unshadowed halves of the microfibrils by the electron beam. W.G.C.

460. Time dependence of mechanical breakdown in bundles of fibers. V. Fibers of Class A-2. BERNARD D. COLEMAN. *J. Appl. Phys.*, **30**, 1959, 720. Mellon Institute, Pittsburgh 13, Pennsylvania. The theory of mechanical breakdown in bundles of class A-2 fibers, whose strength depends on the speed of measurement, is used to find the conditions under which time-dependence effects can be neglected in calculations of relationships between the strength of bundles and the strength of their constituent filaments. (The classical theories of the strength of bundles do not consider time dependence.) Tables and graphs are presented which give the ratio, ϵ_A , of the strength of an infinite ideal bundle to the mean strength of its filaments as a function of the coefficient of variation, $\sigma_1/E_1(f^*)$, in the strength of the filaments. It is shown that, under certain limiting conditions, ϵ_A for infinite bundle of class A-2 fibers is the same as it would be for an infinite bundle of classical fibers with an equal value of $\sigma_1/E_1(f^*)$, and a numerical investigation is made of the rapidity with which this limiting behaviour is approached. AUTHOR

461. The structure and properties of paper.—XIII. A structural interpretation of tensile stress-strain behaviour. A. W. MCKENZIE, *Aust. J. Appl. Sci.*, 1960, **11**, 451–461. Division of Forest Products, C.S.I.R.O., Melbourne. A large number of stress-strain curves of paper have been examined. As interfibre bonding increases, the elastic and post-yield slopes reach a constant value. It is suggested that the attainment of this constant value is achieved when inhomogeneities in stress distribution have been eliminated. Consideration of the implications of these and other known stress-strain characteristics has led to the development of a theory of stress-strain behaviour based upon stress losses due to bond rupture. AUTHOR

462. Some observations on the relationship between mechanical properties and submicroscopic structure of cellulose tire cords. D. S. JACKSON and A. SANDIG, *Text. Res. J.*, 1961, **31**, 421–433. Courtaulds (Canada) Limited, Cornwall, Ontario, Canada. An attempt is made to describe the physical properties and fine structure of high tenacity yarns (used in tyres) particularly those made by the viscose process. Results obtained on 12 commercial yarns suggest that strengths of yarns are dominated by fine structure characteristics such as molecular configuration rather than D.P. These characteristics for the newer cellulosic tyre yarns are such that the yarns have a contractive response to swelling induced by caustic soda; further, an overall improvement in mechanical properties is accompanied by a tendency to less crystallite perfection. N.W.

463. Aggregation of methyl cellulose in solution. W. KUHN, P. MOSER and H. MAJER, *Helvetica Chimica Acta*, 1961, **44**, 770–791. Physikalisch-Chemisches Institut, Basle University, Switzerland. Electric birefringence (Kerr effect), dielectric constant (at 1 to 5 10^8 cycles/second), and specific viscosity of aqueous solutions of different fractions of methyl cellulose are measured at various concentrations and temperatures. In certain conditions aggregates of about 400 parallel molecules are formed, the viscosity being practically unaffected. The aggregates have a negative

SECTION D

and the molecules a positive electric birefringence owing to mutual cancellation of dipole moments in a direction parallel to the molecules in the aggregate. [German]

464. Development and comparison of two X-ray methods for determining the crystallinity of cotton cellulose. JAMES H. WAKELIN, HESTER S. VIRGIN, and EUGENE CRYSTAL, *J. Appl. Phys.*, 1959, **30**, 1654. Textile Research Institute, Princeton, New Jersey. Two X-ray methods have been developed for determining the crystallinity of cellulose using a Geiger Counter spectrometer. The two methods were applied to six native cotton varieties, to a cross-bred variety, and to two cottons chemically modified with ethylamine. The X-ray scattering curves for each of the nine samples were compared with those from a highly crystalline sample, a cotton hydrolyzed in HCl, and an amorphous cotton sample to provide a relative measure of crystallinity, or crystalline index. With fully corrected data the average crystalline index of the six cotton varieties was found to be 68.3 and 78.7 per cent. by the correlation and by integral methods, respectively. The crystalline indices of the remaining samples determined by the correlation and by the integral methods are, respectively, cross-bred cotton (SXP), 54.3 and 77.2 per cent; cotton treated with anhydrous ethylamine, 29.7 and 50.9 per cent; and cotton treated with 75 per cent aqueous ethylamine 28.3 and 50.3 per cent. AUTHOR

465. Interaction of model peptides with water and lithium bromide. J. BELLO and H. R. BELLO, *Nature, Lond.*, 1961, **190**, 440-441. Dept. of Biophysics, Roswell Park Memorial Institute, Buffalo 3, New York, U.S.A. The increased viscosity of model peptides in lithium bromide solutions is discussed, and possibilities as to its cause are suggested.

W.G.C.

Section E

PASTES AND SUSPENSIONS

466. Relations of Young's modulus to swelling and vapour pressure of gels. W. KUHN, *Helvetica Chimica Acta*, 1961, **44**, 1017-1024. Physikalisch-Chemisches Institut, Basle University, Switzerland. The change of partial pressure of the swelling agent consequent on a change of volume of a gel is related theoretically to the Young's modulus and Poisson's ratios of the gel in the cases of isotropic, one-dimensional and two-dimensional swelling. The relations are applied to rubber-like gels. [German]

467. The two kinds of Young's modulus for gels. W. KUHN, *Helvetica Chimica Acta*, 1961, **44**, 927-935. Physikalisch-Chemisches Institut, Basle University, Switzerland. The values of Young's modulus and Poisson's ratio for a gel in contact with a swelling agent depend on whether deformation occurs at constant composition or at constant partial vapour pressure of the swelling agent. Theoretical relations are derived for changes of vapour pressure and free energy for a swollen gel which is deformed in the absence of and then brought into contact with excess swelling agent. [German]

468. On the flow of a non-Newtonian liquid on a rotating disk. A. ACRIVOS, M. J. SHAH, and E. E. PETERSEN, *J. Appl. Phys.*, 1960, **31**, 963. Department of Chemical Engng. University of California, Berkeley, California. The equations describing the flow of a power-law non-Newtonian fluid on a rotating disk have been solved in general form. This makes it possible to calculate how the shape of an initial surface contour will vary with time and to investigate the possibility of producing uniform films by applying the materials to a rapidly spinning disk. It is shown that the latter process, which has potential industrial applications, has a much better chance of succeeding if the fluid is Newtonian than if it is not, in the sense that whereas for a Newtonian substance centrifugation will smooth out irregularities in the surface contour, for a non-Newtonian fluid even an initially uniform thickness will be deformed by rotating the plate. AUTHOR

469. Theory of non-Newtonian flow. III. A method for analyzing non-Newtonian flow curves. WAN KYUE KIM, NISHIO HIRAI, TAIKYUE REE, and HENRY EYRING, *J. Appl. Phys.*, 1960, **31**, 358. University of Utah, Salt Lake City, Utah. The historical development of the rate theory of viscosity is briefly reviewed. The Ree-Eyring equation of generalized viscosity:

$$\eta = \sum_{n=1}^m (x_n \beta_n / a_n) (\sinh^{-1} \beta_n \dot{\gamma} / \beta_n \dot{\gamma})$$

is applied successfully in a variety of cases. (For the definitions of the symbols in this equation, reference is made to the text.) We develop here a new method for determining the parameters x_n/a_n and β_n in Eq. (A). According to the method, these parameter are uniquely determined. When we used the parameters determined by the new method, the viscosities for η_s solutions of poly- γ -benzyl-L-glutamate were calculated from Eq. (A). It is found that Eq. (A) is much superior to other frequently applied viscosity equations. Upon calculating the Newtonian viscosities for fairly concentrated solutions of polyacrylonitrile and of nitrated pine pulp, the following empirical formula is found:

$$\eta_s \approx KC^2 M \beta_p^3$$

Here K is a characteristic constant for a solution; C the concentration; M the molecular weight; and β_p is the "principal" relaxation time. In dilute solutions, Eq. (B) reduces to the form $\eta_s \approx K'CM$. AUTHOR

470. The non-Newtonian viscosity of polymers in relation to their molecular conformation. E. PASSAGLIA, J. T. YANG, and N. J. WEGEMER, *J. Polym. Sci.*, 1960, **47**, 333-348. American Viscous Corporation, Marcus Hook, Pennsylvania, U.S.A. The non-Newtonian viscosities of polystyrene and polyisobutylene were measured in various solvents over a wide range of shearing stress. The shear dependence of the intrinsic viscosity appears to be closely related to the molecular configuration in the solvent, and this concept is discussed in some detail.

SECTION E

471. The recognition of gel-formation in PVC pastes by means of viscosity measurements. K. DISMER and F. PATAT, *Rheologica Acta*, 1961, **1**, 565-571. Rheinberg/Rhld., Ludwigstrasse, 11, Germany. A 12 per cent solution of PVC in dioctyl phthalate is prepared at 160°C and cooled to 100°C where the viscosity is measured as a function of time using a capillary viscometer. The Weissenberg correction is used to derive the shear stress-rate-of-shear relation. [German]

472. The influence of ionic strength on the viscosity of ribonucleic acid and other polyelectrolytes. R. A. COX, *J. Polym. Sci.*, 1960, **47**, 441-447. The Weizmann Institute of Science, Rehovoth, Israel. The viscosity of a number of diverse polyelectrolytes varies with the concentration, C , of added electrolyte according to the relation :

$$[\eta] = [\eta_0] (C/C_0)^{-m}$$

where the suffix 0 refers to any reference solution and m is a constant whose value depends on the permeability of the polyion. Polynucleotides, however, exhibit different behaviour which indicates an unusually large molecular contraction between sodium chloride concentrations of 1 and 10 mM.

473. Deformation, elastic- and relaxation-properties of liquid-plastic colloidal systems. A. A. TRAPEZNIKOFF, *Rheologica Acta*, 1961, **1**, 617-629. Institute for Physical Chemistry, Moscow. The shear behaviour of highly elastic liquids (aluminium soaps in oils, rubber in dekaline) is studied in concentric cylinder apparatuses. At constant shear rate, the shear stress (as a function of time) passes through a maximum; the values of shear stress and shear strain at this maximum are determined over a range of shear rates and concentrations. The recoverable shear strain is also measured at different times of shearing. Extensive data are given; these have been published in the Russian literature. [German]

474. Viscous properties of plastic-disperse systems. V. P. PAVLOV, G. V. VINOGRADOV, V. V. SINIZYN and J. F. DEINEGA, *Rheologica Acta*, 1961, **1**, 470-490. Moscow. Flow curves of various greases and oil/soap systems are obtained; the results of using capillary and rotational concentric-cylinder viscometers are compared. Temperature changes in the gap of the latter are measured. Photographs, taken with polarized light, of systems flowing through a capillary of rectangular cross section are given. Dielectric loss data are given. [German]

475. On the determination of viscosity in retarded elastic deformation process. S. PETER, *Rheologica Acta*, 1961, **1**, 519-525. Hanover, Eichstr. 16, Germany. For a system consisting of an elastic structure in a viscous medium, an equation is derived which enables the viscosity of the latter to be determined from the time-dependence of the elastic deformation. The analysis is applied to data on bitumens. [German]

476. Elastic structure-rigidity in plastic-disperse systems. G. V. VINOGRADOV and P. V. PAVLOV, *Rheologica Acta*, 1961, **1**, 455-470. Moscow.

VOL.
4
1961

Extensive measurements of shear stress and shear recovery as a function of shear strain and rate-of-strain are reported on various greases. Three concentric-cylinder apparatuses of different gap sizes are used. [German]

477. Structure formation in disperse and in high molecular weight systems; types of structure and their rheological properties. P. A. REHBINDER and N. W. MICHAILOW, *Rheologica Acta*, 1961, **1**, 361-370. Moscow University. The difference in rheological properties (rigidity, plasticity, elastic recovery, thixotropy) exhibited by crystalline and non-crystalline systems is discussed in relation to difference of structure. [German]

478. Effect of composition and polymorphic form on the hardness of fats. R. O. FEUGE and W. A. GUICE, *J. Amer. Oil. Chem. Soc.*, 1959, **36**, 531-534. Southern Regional Research Laboratory, New Orleans, Louisiana. Using a modified Brinell type of test, the effect of composition and polymorphic form on the hardness of fats was investigated. It was found that the hardness of a given sample of fat was influenced by the degree of tempering to which it had been subjected. Hardness always increased as the components of a fat were converted to higher melting polymorphs. Adding progressively larger amounts of one fat to another generally increased or decreased the hardness of the mixture in a more or less uniform manner. Apparently the hardness index of a given fat decreases as the crystal size increases.

479. The dependence of the rheological properties of bitumens on temperature and on the addition of activated fillers and softeners. N. W. MICHAILOV and P. A. REHBINDER, *Rheologica Acta*, 1961, **1**, 629-639. Moscow. Shear stress-shear data are obtained in a concentric cylinder apparatus in which the shear stress and the shear rate can be kept constant in turn. The ranges of variables are: 5×10^{-4} to 120 sec^{-1} ; 50 to $5 \times 10^8 \text{ dynes/cm}^2$; 40°C to 160°C . [German]

480. Fundamental aspects of thixotropy in soils. J. K. MITCHELL, *Proc. Amer. Soc. Civ. Engrs.*, 1960, **86** (SM3), Pt. 1, 19-52. Thixotropic phenomena are described and previous investigations on the behaviour of thixotropic systems are summarised. A hypothesis for thixotropic behaviour based on initial non-equilibrium of interparticle forces after remoulding or compaction, and the effects of this non-equilibrium on subsequent structure changes within the soil, is offered as one possible explanation of the phenomenon. The experimental results presented are consistent with this hypothesis. Some of the practical aspects of thixotropy are considered.

481. Plasticity and elasticity of clay pastes. A. A. BAUDRAN, *Rheologica Acta*, 1961, **1**, 598-602. Centre National d'Études et Recherches Céramiques, Paris. An apparatus for measuring torque and twist of a cylindrical sample of clay is described. For a given amount of shear strain, it is found that the magnitude of the recoverable shear is independent of the applied shear stress. [French]

SECTION F

Section F

LIQUIDS

482. Flow of liquid hydrocarbons in porous Vycor. P. DEBYE and ROBERT L. CLELAND, *J. Appl. Phys.*, 1959, **30**, 843. Baker Laboratory of Chemistry, Cornell University, Ithaca, New York. Experimental investigation of the flow rates of normal paraffins in porous Vycor glass shows that there are deviations from the viscosity dependence required by Poiseuille's Law. A discussion of the application of capillary models to describe flow in porous media in terms of the measured porosity and surface-to-volume ratio points out that such models are not generally applicable, though they give useful results for some purposes. An estimate of the permeability predicted by Poiseuille's Law is made by an empirical method which uses gas flow measurements in the Knudsen flow region. The equations of slip flow as derived for gases do not explain the experimental deviations from Poiseuille's flow. The concept of a slipping adsorbed layer of molecular thickness at the wall of a capillary is combined with the usual Poiseuille treatment for the interior to give a result which is compatible with experiment.

AUTHOR.

483. Effect of viscosity on the splash caused by a drop of water falling into a mixture of glycerol and water. A. G. DAVIS PHILIP, *J. Appl. Phys.*, 1960, **31**, 727. Department of Physics, New Mexico State University, Las Cruces, New Mexico. The effect of viscosity and velocity on splashes produced by low-velocity water drops was investigated by means of high-speed photography. Graphs have been constructed showing the effects on the time of duration of the various stages of the splash and a dimensional analysis in terms of the Reynold's number and Froude's number has been made.

AUTHOR

484. Effect of viscosity of the media on the half-wave potential and the diffusion current in polarography. S. N. MUKHERJEE, A. M. GHOSH and MRS. A. CHAKRAVARTY, *J. Sci. Industr. Res.*, 1961, **20B**, 77-78. Physical Chemistry Labs., Jadavpur University, Calcutta, India. The effect of varying the viscosity η of the medium (by the use of glycerine) on the half-wave potential and diffusion current i_d has been studied with reference to Cd and Zn as the reducing ions. The relation $i_d \eta^{1/2} = \text{constant}$ has been found to hold throughout the entire range of viscosity of the medium investigated.

AUTHOR

485. Dielectric relaxation in relation to viscosity. J. SOBHANADRI, *J. Sci. Industr. Res.*, 1961, **20B**, 43-46. Physics Dept., Andhra University, Waltair, India. The relaxation times τ of α -bromonaphthalene, α -nitronaphthalene, and of o -, m -, and p -bromotoluene have been determined at different solvent viscosities adopting the Cole-Cole arc plot method; their dipole moments have also been determined. The distribution parameter is observed to increase with increasing solvent viscosity.

AUTHOR

GENERAL

486. Effect of dissolved air on the viscosity of water. W. A. CAW and R. G. WYLIE, *Nature, Lond.*, 1961, **189**, 995-996. National Standards Laboratory, C.S.I.R.O., Sydney, Australia. Using sealed suspended-level viscometers incorporating fine platinum contacts, by means of which electronic timing equipment was triggered, the viscosity of air-saturated water has been measured relative to that of air-free water. Temperature control was maintained to within $\pm 7 \times 10^{-4}$ °C, measurements being made with a platinum resistance thermometer. Within a set, the concordance of flow-times was 1- part in 5×10^4 . The comparisons at 20°, 25°, and 30°C, showed that the effect of dissolved air was insignificant for present standards requirements. W.G.C.

487. Viscometric behaviour in relation to evaporation of fruit purees. J. C. HARPER, *Food Tech.*, 1960, **14**, 557-561. Agricultural Engineering Department, University of California. The performance of a wiped film evaporator in concentrating apricot, peach and pear purees was investigated and the viscosity characteristics of the products established. It was found that the viscosity (behaviour) was well represented by the equation

$$\tau = K\dot{\gamma}^n$$

Overall heat transfer coefficients correlated well with values of K , and performance was found to be much better for non-Newtonian fluids than for Newtonians of equivalent consistency.

Section G

GENERAL

488. Theoretical classification of rheological properties of real bodies. R. BUVET, *Rheologica Acta*, 1961, **1**, 669-672. Ecole Supérieure de Physique et de Chimie Industrielles, Paris. [French]

489. A classification of rheological properties of bodies. M. KÉPÉS, *Rheologica Acta*, 1961, **1**, 672-674. Ethylén Plastique S.A., Paris. [French]

490. Proposed nomenclature for linear viscoelastic behaviour. H. LEADERMAN and F. SCHWARZL, *Rheologica Acta*, 1961, **1**, 674-676. National Bureau of Standards, Washington, D.C., U.S.A.

491. Viscosity of dusty gases. W. T. SPROULL, *Nature, Lond.*, 1961, **190**, 976-978. Western Precipitation Division, Joy Manufacturing Co., Los Angeles, U.S.A. The observed reduction in viscosity of a gas when the dust concentration is increased is attributed to a decrease in the mean free path of the gas molecules. It is suggested that this results from the effective diameter of each dust particle being increased by a boundary layer of gas adhering to it. W.G.C.

492. Determination of molecular dimensions from rheological data. A. PETERLIN, *Makromol. Chemie*, 1959, **34**, 89-119. Univ. of Ljubljana, Yugoslavia. A survey of the existing possibilities of molecular size and shape determined from rheological experiments is given. Porous sphere models, necklace models, packed coils, corpuscular and linear particles are among the configurations considered.

Summaries of papers to be presented at a Conference on Rheological Techniques, to be held by The British Society of Rheology and the Non-Destructive Testing Group of the Institute of Physics and Physical Society in September, 1961

Electrical methods for the measurement of viscoelastic behaviour under cyclic stress.

A. J. BARLOW, G. HARRISON, J. RICHTER, H. SEGUIN and J. LAMB (Imperial College).

Purely mechanical methods of evaluating the shear response of liquids are limited to comparatively low frequencies of cyclic stress of the order of a few hundreds cycles per second. Before the introduction by MASON (1947) of a piezoelectric transducer as a means of viscosity measurement, investigations were confined to frequencies below about 20 Kc/s for which mechanical and electromagnetic devices were employed. In this range measurements on liquids having viscosities of a few poise or less showed no reduction of the dynamic viscosity with frequency, and elastic effects were absent.

The frequency range can be extended to about 200Kc/s by the use of piezo-electric crystals vibrating torsionally. Measurements at higher frequencies, up to 10^8 c/s or above can be made using quartz crystals resonant in the thickness-shear mode. For still higher frequencies it is possible to generate shear waves by direct excitation of a quartz rod or disc inserted into a cavity resonator. Measurements of the shear modulus have been made at 1500 Mc/s and preliminary experiments at 3000 and 10,000 Mc/s are in progress.

In practice measurements are made of the components of the shear impedance, from which the associated values of dynamic viscosity and shear modulus are readily deduced.

A description is given of the following experimental systems :

1. Resonant torsional quartz crystals operating in the frequency range 20 Kc/s to 150 Kc/s which are used for measurements of non-conducting liquids having viscosities below about 5 poise.
2. Torsional wave propagation in long rods immersed in a liquid. This method is applicable to liquids having viscosities above 5 poise and can be used over the frequency range 10 Kc/s to 100 Kc/s.
3. Shear wave propagation in fused quartz and the measurement of the reflection coefficient at a fused-quartz liquid interface. Thickness-shear vibrating quartz crystals are employed as transducers over the frequency range 3-250 Mc/s.
4. Shear wave propagation in a rod of crystal quartz and the measurement of reflection coefficient at a quartz-liquid interface. The crystal is directly excited by placing one end in a tunable cavity which can be made resonant in the frequency range 250 Mc/s to 1500 Mc/s.

5. Shear wave propagation through a thin quartz disc which is contained in a re-entrant cavity resonating at frequencies in the region of 3000 Mc/s. The plane surfaces of the quartz disc are loaded by a thin film of the liquid under test.

A description is given of the application of these various techniques to the measurement of the viscoelastic properties of liquids under high hydro-static pressure.

The Oscillating Disc Viscometer

R. ROSCOE (King's College, Newcastle)

The viscometer usually associated with the name of O. E. MEYER is extremely simple to construct and has in the past been used for a number of viscosity measurements, particularly on liquid gases. Inaccurate results were obtained, partly because incorrect theoretical formulae were used for calculation and partly because of unsuspected sources of experimental error. An adequate theory of the instrument has recently been given by AZPEITIA and NEWELL, and the practical use of their formulae (also applicable to oscillating cylinder viscometers) is explained in the present paper. The elimination of experimental errors is also discussed, and it is shown by a series of measurements on the viscosity of water that absolute results can be obtained with an accuracy much better than one per cent.

Evaluation of Pseudo-Plastic Materials by Cone Penetrometers

F. J. MOTTRAM (Gestetner Ltd., London)

The evolution of cone penetrometer studies is traced up to the derivation of a fundamental equation for yield value by REHBINDER and AGRANAT. Consequences of this equation are discussed, including the significance of the exponent n and its dependence upon the physico-chemical structure of the material under test. A description of the experimental procedure devotes much emphasis to sample preparation. Collected results are given which demonstrate the degree of reproducibility of yield values using cones of different vertical angles and loadings. A survey of some twelve homologous materials reflects a relationship between cone penetrometer yield values and those obtained from flow curve data. Viscosities at very low shear rates (4 sec^{-1}) show a much slighter correlation with cone results.

The Static Measurement of Yield Stress

G. BOARDMAN and R. L. WHITMORE (Dept. of Mining Engng.,
University of Nottingham)

Dynamic methods of measuring yield stress require the stress-rate of shear characteristics of a fluid to be extrapolated to zero rate of shear. Where an accurate value is required this extrapolation can be unreliable and a static measurement is to be preferred.

An apparatus in which the yield stress of a Bingham-type fluid is obtained directly from the static pull exerted on a plate immersed in the fluid is described. By proving experimentally that Archimedes Principle holds for Bingham-type fluids it is shown that the method is justifiable. The influence of the shape, surface, orientation and creep of the plate on the measurements is examined and some results obtained with clay suspensions are compared with those derived from the extrapolation of the stress/rate of shear curves given by a rotating-cylinder viscometer.

The Measurement of the Properties of Visco-Elastic Liquids

K. A. LAMMIMAN and J. E. ROBERTS

(Esso Research Ltd., Abingdon, Berks)

Methods of measurement of the properties of visco-elastic liquids, when subjected to either unidirectional or oscillatory laminar shear strain, are discussed, with particular reference to the latest model Rheogoniometer. A new technique for the determination of phase difference and a null method for the measurement of the total normal force are described; other types of null systems and methods of measurement of forces are outlined. The applications of the techniques so far developed are briefly described.

Determination of the concentration changes of fine particulate suspensions flowing through narrow capillary tubes.

H. W. THOMAS (St. Mary's Hospital, W.2)

A method has been devised for detecting the changes in mean concentration which occur when a particulate suspension flows through a narrow capillary tube. The suspending phase is labelled with a suitable γ -emitting radio-active isotope. The flow of the suspension through the tube is arrested instantaneously, and the radioactivity contained within a fixed length of the bore determined by placing the isolated tube in a jig between two scintillation counters. The jig ensures that the geometry is strictly reproducible, and by comparing this count with that obtained when the same tube is filled with the separated suspending phase only, it is possible to calculate the actual mean concentration of the flowing suspension. As described here, the method is only suitable for the study of concentrated suspensions. Preliminary measurements on suspensions of human red cells flowing through glass capillary tubes have demonstrated the expected decrease in concentration with decrease in the capillary bore. Measurements are being continued with the aim of ascertaining the relative contributions of the Vand wall-effect and of the Dixon-Blair "sigma" effect to the anomalous viscosity of particulate suspensions as measured in capillary instruments.

A Reliable Method of Determining Extinction Angles of Streaming Birefringent Liquids

H. JANESCHITZ-KRIEGL (Central Laboratory T.N.O. Delft, the Netherlands)

When streaming birefringence is investigated with the aid of a Couette type rotor unit, parasitic birefringence of window-glasses may cause systematic deviations of extinction positions at low velocity gradients. The present paper describes a compensation method which largely eliminates influence of a weak, homogeneous and time independent proper double refraction of the window-glasses. As a prerequisite, a novel type of window, construction details of which will be published shortly, was developed. It allows reliable sealing of the rotor unit without giving rise to the generation of an unhomogeneous additive double refraction of strain in the window-glasses. This is achieved by avoiding cementing or squeezing between packing rings.

Measurement of the Elastic Modulus of Thin Gelatin Layers

D. W. JOPLING (Kodak Limited, Harrow, Middlesex)

Several methods have been tried for measuring the elastic modulus of coated layers both dry and swollen.

The Young's Modulus of a dry thin gelatin layer under conditions of controlled humidity has been measured by simple extension of strips. Special coatings have to be made so that the layer may be stripped from the support on which it is coated and dried. At high humidity, or at lower humidities with plasticised gelatin layers, rapid creep occurs and it is difficult to measure the initial elastic extension on loading the film. A dynamic method was tried in which a strip of the film was hung from a transducer with a small weight on the free end and the frequency of resonance of the strip was measured. From this the Young's modulus could be calculated. Difficulties were experienced with spurious multiple resonances. Similar effects have been noted by Fitzgerald. It was also found that the results were not always in agreement with those obtained by simple extension.

Attempts have also been made to measure the rigidity modulus of coatings after swelling in water by a "micro Bloom" method. A small plunger which forms the shaft of a differential transformer was placed on the surface and the indentations under different loads were measured. It was found that the results obtained were highly dependent on the thickness of the layer.

A mathematical analysis for the cases of free slip and no slip between the layer and the plunger showed that in both cases the force required for a given deformation was proportional to the

$$\frac{(\text{radius of the plunger})^4}{(\text{thickness of the layer})^3}$$

The constants of proportionality in the two cases were different.

References

- FITZGERALD, E. R. (1957) *J. Chem. Phys.* **27**, 1180.
FITZGERALD, E. R. (1957) *Phys. Rev.* **108**, 690.

Apparatus to Determine the Effect of Strain Rate and Temperature on the Tensile Properties of Textile Fibres

I. H. HALL (Cotton, Silk and Man-Made Fibres Research Association, Manchester)

In order to extend knowledge of the visco-elastic behaviour of materials into the region of finite strain, information is required on the dependence of the stress-strain curve on both strain rate and temperature. The instrument to be described enables stress-strain curves to be determined for fibres with breaking loads in the region of 100 to 1000g at strain rates between 5×10^{-3} and 10 sec^{-1} and at temperatures between -70 and $+50^\circ\text{C}$. The instrument will test both highly drawn fibres with extensibilities of the order of 20 per cent and undrawn and highly elastic materials with extensibilities of several hundred per cent. It is believed to be the only single piece of apparatus which will cover such a wide range of conditions.

An Improved Instrument for the Continuous Assessment of Internal Mechanical Losses in High Polymer Solids

P. LORD, E. R. PITHEY, and R. E. WETTON.

An instrument has been developed to enable a continuous determination of the internal mechanical energy losses of small samples of high polymer solids to be obtained over a wider portion of the audio range of frequencies and below at temperatures from -100°C to $+100^\circ\text{C}$. In addition it is possible to use the same device for determining the complex rigidity molecules of the material. Modifications since the design of the first model have enabled a better control of temperature and mounting of specimens to be achieved.

The use of acoustic techniques in molecular physics

R. HOLMES and W. TEMPEST (University of Liverpool)

An ultrasonic pulse transmission method and an audio-frequency tube resonance method for the measurement of sound velocity and absorption in gases are described. A brief account is given of the use of the sound propagation constants obtained from the measurements in determining the factors affecting energy exchange in intermolecular collisions.

A new cone-and-plate and parallel plate apparatus for the determination of normal stress differences in steady shear flow

A. S. LODGE (Department of Mathematics, The Manchester College of Science and Technology).

The differences of normal stress components in steady shear flow of polymer solutions can be calculated from the radial distributions of pressure on the plate of a cone-and-plate and a parallel plate apparatus.¹ A new apparatus² for determining these pressure distributions has been constructed having (in comparison with the Roberts-Weissenberg Rheogoniometer) the following novel features: (i) pressures are measured by means of quick-response diaphragm-capacitance gauges³; (ii) the liquid can either just fill the gap between rotating and fixed members or can extend a long way outside this gap, so that the effect of changes in shape of the free liquid boundary can be studied; (iii) the alignment of the stationary plate is adjustable; (iv) the stationary plate with its attached pressure gauges can be moved perpendicularly to the axis of rotation, so that details of the radial distribution can be studied.

Results of first measurements on two polymer solutions (polyisobutylene in dekaline and poly(methyl methacrylate) in dimethyl phthalate give positive values for the difference of normal stress components $p_{11}-p_{22}$ (p_{11} is the component normal to the shearing surfaces, p_{22} the component normal to surfaces normal to the shearing surfaces and parallel to the streamlines: $p_{22} > 0$ for a tensile stress). These values are several times larger than the magnitudes of pressure observed at the rim of the rotating member; pressures at the rim are always negative.

References

1. A. S. LODGE, *Rheology Abstracts*, (1960), 3, No. 3, 21.
2. N. ADAMS, *Ibid.*, p. 28.
3. A. S. LODGE, *J. Sci. Instrum.*, (1960), 37, 401.

Streaming Double Refraction in Liquids

H. G. JERRARD (Department of Physics, University of Southampton)

The study of the double refraction produced in flowing liquids provides useful information for the determination of molecular size, shape and weight. The quantities required are the birefringence produced and the flow gradient. In this paper the relationship between the birefringence and the molecular polarizability and dimensions is discussed. Details are presented of an apparatus used for this type of work. This consists essentially of two concentric cylinders arranged as in a Couette viscometer with the outer cylinder rotatable to speeds as high as 2500 r.p.m. Gradients of the order of 12000 sec^{-1} can be produced. A cooling system is provided to maintain the liquid at a constant temperature. The outer cylinder is provided with a glass bottom so that linearly polarized light can be made to traverse the liquid in the annular gap

between the cylinders : on emergence it is analyzed by a suitable optical system. The accuracy of the instrument is discussed and some results on solutions of polystyrene in toluene are presented.

Measurement of Double Refraction in Liquids produced by Ultrasonic Radiation

N. C. HILYARD (Department of Physics, University of Southampton)

When a liquid or solution is irradiated with acoustic waves it becomes optically anisotropic and behaves as a uniaxial crystal with its optic axis lying along the direction of propagation of the wave. This effect has been observed in liquids of different viscosities including polymer solutions which show a small birefringence. Measurement of the double refraction induced in the solution gives information on molecular parameters. This technique for investigating solutions is described. The essential parts of the apparatus used in this study are the acoustic wave generator, the cell containing the liquid and the optical arrangement for measuring the double refraction produced. Considerations which have to be taken into account in designing and using the apparatus are discussed. Sources of error, the accuracy that can be obtained and the possibilities of the technique are mentioned.

BOOK REVIEWS

Properties and Structure of Polymers.

ARTHUR V. TOBOLSKY.

John Wiley, New York and London. 331 pp. 116s.

This book contains six chapters : (1) Elasticity and Viscosity, (2) Aspects of Polymer Physics, (3) Mathematical Treatment of Linear Viscoelasticity, (4) Viscoelastic Behaviour of Polymers, (5) Chemical Stress Relaxation, and (6) Polymerisation Equilibria. There are also ten appendices occupying a total of forty pages.

Undoubtedly the principal feature of the book is an authoritative discussion on the viscoelastic behaviour of high polymers. The phenomenological theory of linear viscoelasticity is described in some detail with an emphasis on relaxation phenomena, as distinct from retardation phenomena. Various types of distribution of relaxation times which have been found useful in studying the viscoelastic properties of polymers are examined but similar emphasis is not put on the corresponding distributions of retardation times, nor is the interrelation of the two types of distribution discussed.

The reason for this emphasis becomes evident in chapters 4 and 5 which deal with the observed viscoelastic behaviour of high polymers. Professor Tobolsky and his collaborators are well known for their

OL.
4
961

studies on stress relaxation at constant length in high polymer systems and in these chapters the author has drawn heavily (almost exclusively) on this work. The properties of a wide range of polymers are presented and both the physical and chemical aspects of stress relaxation are discussed. Only brief reference is made to molecular theories of the Rouse-Bueche type. One section is devoted to the use of birefringence measurements in studying viscoelastic properties.

The reviewer found the first one and a half chapters (which must be regarded as introductory to the main business of the book) rather disjointed and tedious, much of it being largely irrelevant to the rest of the book which is well written and stimulating.

It is probably fair to regard the book rather as a considered account of the work of Professor Tobolsky and his co-workers, together with some background material and some references to other work, rather than as a comprehensive review of any particular field of work. Indeed, references cited on any particular subject are more or less confined to those appearing at about the same time as the author's own publications in that field. Later work is frequently not referred to. A fairly extensive literature is cited, some of it without mention in the text and some hitherto unpublished results are presented.

From a rheological point of view it is a pity that no attempt was made to put the subject into perspective with the general background of the rheology of high polymers such as general strain theory, normal stress effects, etc. However, the book can be confidently recommended to anyone with an interest in the rheology of high polymers.

The book is well produced and commendably, though not completely, free from errors. There are good subject and author indexes but the practice of having a separate bibliography at the end of each section makes the author index cumbersome to use and wastes space through repeated repetition of many references.

D. W. SAUNDERS.

Rheology : Theory and Applications Vol. 3.

Edited by F. R. EIRICH. Academic Press, New York and London, 1960. £7 10s.

This volume is the last of the three in a work intended to bring about "a better understanding of the essential unity of rheology" by bringing together papers from all the various areas of this active field. It is intended to complete the picture by concentrating mainly on individual topics and industrial applications. Materials dealt with are latex, printing inks, pastes and paints, sand-water and clay-water mixtures, inorganic glasses, concrete, polymers and lubricants, and processes considered are moulding, spinning and screw extrusion.

The task of reviewing a book of collected papers by many authors is always difficult because the selection of chapters for criticism is bound to be somewhat arbitrary and the quality of those selected may not be representative of the book as a whole.

Most of the authors seem to fulfil their purpose of giving a comprehensive review of their field with copious references. There are, however, some surprising omissions. For instance, in the chapter on concrete by Reiner there is no mention of the effect of vibration on fresh concrete although this is one of the most interesting phenomena in the study of the material, and it is certainly of great technological importance in the production of high quality concrete. Again, reinforced concrete is dealt with briefly, but prestressed concrete earns only a passing reference.

I was not able to find any account of the rheology of blood and other body fluids on which interesting work has been done, nor of the rheology of confectionery or dairy products.

Perhaps even more surprising is that although plastic theory of metals is dealt with in Vol. I, neither there nor in the present volume is there any mention of the important metal forming processes of rolling, forging, extrusion or wire drawing. A great deal of work has been done on all these in the last 10 years.

As in the previous volumes there has been no standardisation of nomenclature, a task which would have been extremely difficult. The symbols used in each chapter are clearly stated at its end however and there is little danger of confusion. Nevertheless it is perhaps disturbing to find conflicting definitions. The confusion regarding thixotropy has still not been resolved; Zettlemoyer and Myers define it simply as time dependent viscosity change, Weltmann following Freundlich fairly closely includes the condition of isothermal reversibility, while Weyl and Ormsby say it is the decrease of yield value if a system is subjected to mild vibrations. In the theoretical chapter of Vol. I it is not mentioned at all.

However, some of the foregoing criticisms are probably mainly comments on the complexity of rheology and its still unsolved problems rather than criticisms of the book itself. They serve to show that it must be read critically and not as a text book containing only indisputable facts.

In general the book is good. The standard of writing is high and each author gives a clear account of his subject. There is a most useful index of 47 pages. The claim in the Preface to Vol. I that "... it offers the novice a very general introduction to many topics, and the advanced reader a ready means of comparing the different viewpoints ... and of studying new material ..." is surely justified.

The three volumes between them certainly cover the greater part of the field of rheology. Altogether about 3000 references to original papers are given and of the total of just over 2000 pages, 159 are devoted to comprehensive author and subject indexes.

The standard of production of all three volumes is excellent; they are well printed on good quality paper and are well bound. A few misprints were detected but these are rare.

There is no doubt that this work is a valuable addition to the literature of rheology and should be available to all rheologists or scientists in any way concerned with work in rheology.

G. H. TATTERSALL.

OL.
4
961

VOL.
4
1961

Section A

THEORETICAL

493. On the integration of the equations of unsteady creep of solid bodies. P. S. KURATOV and V. I. ROSENBLIUM, *Russian J. Appl. Math. and Mech.*, 1960, **24**, 195-199.

494. Two-dimensional elastic inclusion problems. M. A. JASWON and R. D. BHARGAVA, *Proc. Camb. Phil. Soc.*, 1961, **57**, 669-680. Imperial College, London. An account is given of Eshelby's point-force method for solving elastic inclusion problems, and of his equations relating an inhomogeneity to its equivalent inclusion. The introduction of complex variable formalism enables explicit solutions to be found in various two-dimensional cases. Strain energies are calculated. The equilibrium shape of an elliptic inclusion exhibits an interesting feature not previously expected. A fresh analysis of stress magnification effects is developed.

Authors.

495. Surface waves in anisotropic elastic media. V. T. BUCHWALD and A. DAVIS, *Nature, Lond.*, 1961, **191**, 899-900. Department of Applied Mathematics, The University of Sydney, Australia. The propagation of surface waves in anisotropic media is discussed, mainly with reference to crystalline materials.

W.G.C.

496. Thermal stresses in slabs of linear rheological materials. D. CAMPBELL-ALLEN, *Research Report R 19, Civil Engineering Laboratories, The University of Sydney*, April 1960, 26 pp. A theoretical study has been made of the thermal stresses that arise in a slab of material, when one face is suddenly heated, for the cases where the slab has linear viscoelasticity (Maxwell body) and linear elastic after-effect (Kelvin body). Particular attention has been paid to tensile stresses, and the results show that little relief of tensile stress is to be expected from the rheological nature of the material in comparison with an elastic material and that in the case of the Kelvin body substantial redistributions of stress will occur.

Author.

497. An extension of Alfrey's analogy to thermal stress problems in temperature-dependent linear viscoelastic media. H. H. HILTON and H. G. RUSSELL, *J. Mech. Phys. Solids*, 1961, **9**, 152. Department of Aeronautical Engineering, University of Illinois, Urbana, Illinois. The elastic-viscoelastic analogy due to Alfrey is extended to incorporate thermal stress problems in nonhomogeneous linear viscoelastic media. It is shown that the thermal stresses in a body possessing temperature-dependent linear viscoelastic properties can be deduced from an equivalent elastic body.

498. Tentative equations for the propagation of stress, strain and temperature fields in viscoelastic solids. S. C. HUNTER, *J. Mech. Phys. Solids*, 1961, **9**, 39. Brown University, Providence, R.I. A thermodynamic analysis of the "thermo-rheologically simple" solid proposed by

SECTION A

Schwarzl and Staverman (1952) leads to a set of thermomechanically coupled equations for the propagation of stress, strain and temperature fields in viscoelastic solids. The propagation of harmonic dilational waves is investigated in a linear approximation whose range of validity is ascertained; thermomechanical coupling effects appear to be more severe than for elastic solids. Author.

499. Probability of initial ring closure in the restricted random-walk model of a macromolecule. B. J. HILEY and M. F. SYKES, *J. Chem. Phys.*, 1961, **34**, 1531. Wheatstone Physics Laboratory, King's College, London, England.

500. Molecular statistics of vinyl polymers. Y. SUZUKI, *J. Chem. Phys.*, 1961, **34**, 79. College of Arts and Sciences, Chiba University, Chiba, Japan. A formula is proposed to describe the end-to-end distance and the total dipole moment of the vinyl polymer $(CH_2CHX)_n$. Author.

501. Expected square of the length of isotactic vinylic hydrocarbon-type chains. V. E. MEYER, J. B. KINSINGER and P. M. PARKER, *J. Chem. Phys.*, 1961, **34**, 1429. Kedzie Chemical Laboratory, East Lansing, Michigan. The mean square length of long isotactic vinylic hydrocarbon-type chains is calculated. The Markov chain formalism is employed for this calculation. The problem of excluded volume is not considered. Author.

502. Thermodynamic relations for high elastic materials. P. J. FLORY, *Trans. Faraday Soc.*, 1961, **57**, 829-838. Mellon Institute, 4400 Fifth Av., Pittsburg, Pa. The general relationship between stress and strain is derived for an amorphous cross-linked polymer by considering its Helmholtz free energy as the sum of two energies. One for the liquid-like contribution due to interchain interactions and which is a function of temperature and volume and another, an elastic energy, which is a function of temperature and the displacement gradient tensor. This is derived from the theory of rubber elasticity. A general basis for interpreting thermoelastic measurements on high elastic materials is provided. W.H.B.

503. Theory of solutions. III. Thermodynamics of aggregation or polymerization. T. L. HILL, *J. Chem. Phys.*, 1961, **34**, 1974. Department of Theoretical Chemistry, Cambridge University, Cambridge, England. Polymeric and colloidal systems are usually polydisperse, containing subspecies differing only in degree of polymerization n . Let $P(n)$ be the fraction of polymer molecules of size n . Our main interest in this paper is to investigate how the thermodynamic functions of the system change when the distribution function $P(n)$ changes, as, for example, in a kinetic study in which $P(n)$ evolves sufficiently slowly with time or in thermodynamic studies on different samples of the same polymer.

Author, abridged.

VOL.
4
1961

THEORETICAL

504. Concentration dependence of polymer chain configurations in solution. H. YAMAKAWA, *J. Chem. Phys.*, 1961, 34, 1360. Department of Textile Chemistry, Kyoto University, Kyoto, Japan. The segment distribution functions are formally derived as a power series in concentration. The mean-square radius of gyration and end-to-end distance at finite concentrations are calculated by using the general equations derived and introducing the modified random flight model. The results show that the polymer chain dimension decreases with increasing concentration. Then the concentration-dependent term in the intramolecular intensity function in light scattering is evaluated. It is pointed out that the separation of this term and the intermolecular correlation leads to the possibility of estimation of the polymer chain dimension at finite concentrations by light-scattering measurements. Finally, the Huggins constant k' in the viscosity-concentration relation is phenomenologically calculated. The concentration dependence of polymer chain dimensions proves to explain satisfactorily the effect of solvent power on the k' constant. Author, abridged

505. Statistics of orientation effects in linear polymer molecules. E. A. DiMARZIO, *J. Chem. Phys.*, 1961, 35, 658. American Viscose Corporation, Research and Development Division, Marcus Hook, Pennsylvania. The combinatorial term for the number of ways to pack together Nx linear polymers (x mers) is evaluated as a function of the number of molecules in each permitted direction for the case of straight rigid rods. The permitted directions can be continuous or discrete. Liquid crystals are discussed and another phase, tentatively identified with the cholesteric phase, is found to exist in addition to the previously predicted nematic phase. A qualitative prediction of the change in the entropy of packing as a function of stretch explains the initial deviation of the experimental stress-strain curve from the previous theoretical predictions.

R.W.W.

506. Intrinsic viscosity of stiff chains. R. ULLMAN and A. MUZYKA, *J. Chem. Phys.*, 1961, 34, 1461. Institute for Polymer Research, Polytechnic Institute of Brooklyn, Brooklyn, New York. The intrinsic viscosity of a solution of partially coiled polymer molecules is being investigated using a procedure developed by Burgers and extended by Kirkwood and Riseman. A serious difficulty in the numerical computations to solve the resulting equation is discussed.

R.W.W.

507. Relaxation of laminar flow with reference to streaming birefringence decay. C. A. HOLLINGSWORTH and W. T. GRANQUIST, *J. Chem. Phys.*, 1961, 34, 1814. Department of Chemistry, University of Pittsburgh, Pittsburgh, Pennsylvania. Equations are obtained which express the decay of motion of fluids between concentric cylinders, parallel plates, and in tubes. Numerical examples are given which indicate that the time required for the flow to decay may not always be short compared to the streaming birefringence relaxation times.

Authors

508. Theory of light scattering by thin rod-like macromolecules in a liquid subjected to shear. K. OKANO and E. WADA, *J. Chem. Phys.*, 1961, 34, 405. The Institute of Physical and Chemical Research, Tokyo, Japan.

SECTION A

The light scattering by thin rod-like particles in a liquid subjected to shear is calculated on the basis of the Rayleigh-Gans treatment. The calculations are made for both unidirectional laminary flow and for flow of periodically alternating direction. The calculation is carried out by two methods: the interference factor P is expressed in terms of a power series of G/D , where G and D are the rate of shear and the rotatory diffusion constant, respectively, of the rod rotating around its minor axis. This treatment is applicable to sufficiently low G/D values. The result for a very wide range of rate of shear is obtained by using the Peterlin distribution function of particle axis. Numerical calculation shows that both results agree in a region of G/D below about two if the axial ratio is large enough. The theoretical results appear to agree with the experimental ones.

Authors

509. Free-volume model of the amorphous phase: glass transition.

D. TURNBULL and M. H. COHEN, *J. Chem. Phys.*, 1961, **34**, 120. General Electric Research Laboratory, Schenectady, New York. Free volume v_f is defined as that part of the thermal expansion, or excess volume Δv , which can be redistributed without energy change. Assuming a Lennard-Jones potential function for a molecule within its cage in the condensed phase, it can be shown that at small Δv considerable energy is required to redistribute the excess volume; however, at Δv considerably greater than some value Δv_g (corresponding to potentials within the linear region), most of the volume added can be redistributed freely. The transition from glass to liquid may be associated with the introduction of appreciable free volume into the system. According to our model all liquids would become glasses at sufficiently low temperature if crystallization did not intervene. The experience on the glass formation is consistent with the generalization: at a given level of cohesive energy the glass-forming tendency of a substance in a particular class is greater the less is the ratio of the energy to the entropy of crystallization.

Authors, abridged

510. Calculations of elastic moduli of polymer crystals: II. Terylene.

L. R. G. TRELOAR, *Polymer*, 1960, **1**, 279-289. British Rayon Research Association, Manchester, England. The value of Young's modulus E for the crystal of Terylene in the direction of the chain axis is calculated from the force constants for bond stretching and valence angle deformation. The presence of the benzene ring in the structure makes this problem less straightforward than that of the simple linear chain structures, polyethylene and nylon, considered in a previous paper by the author. The resultant value of E is 1.22×10^{12} dyn/cm².

Author

511. Calculations of elastic moduli of polymer crystals: III. Cellulose.

L. R. G. TRELOAR, *Polymer*, 1960, **1**, 290-303. British Rayon Research Association, Manchester, England. Continuing the method of treatment already applied to the polythene, nylon and Terylene crystals, the present paper contains a calculation of the modulus of the cellulose crystal in the direction of the chain axis on the basis of the force constants for bond stretching and valence angle deformation. The resultant modulus, namely 5.65×10^{11} dyn/cm², is considerably lower than earlier estimates,

THEORETICAL

based on a different model of the structure. It is also significantly lower than the observed moduli of highly oriented dry cellulose fibres, which may be as high as 1.1×10^{12} dyn/cm². Since the modulus of the fibre must be lower than that of the crystal, there is thus a serious discrepancy to be accounted for. It is suggested that this is due to the neglect of secondary forces in the theoretical treatment. Author

512. On the kinetic theory of dense fluids. VI. Singlet distribution function for rigid spheres with an attractive potential. S. A. RICE and A. R. ALLNATT, *J. Chem. Phys.*, 1961, **34**, 2144. Department of Chemistry and Institute for the Study of Metals, University of Chicago, Chicago, Illinois.

513. On the kinetic theory of dense fluids. VII. The doublet distribution function for rigid spheres with an attractive potential. A. R. ALLNATT and S. A. RICE, *J. Chem. Phys.*, 1961, **34**, 2156. Department of Chemistry and Institute for the Study of Metals, University of Chicago, Chicago, Illinois.

514. An extended hole theory of liquids. G. E. BLOMGREN, *J. Chem. Phys.*, 1961, **34**, 1307. Parma Research Laboratory, Union Carbide Corporation, Parma, Ohio. The hole theory of liquids has been extended to include the effect of all configurations of particles and holes on the partition function. The potential energy of a particle in a cell surrounded by a given number of particles and holes is approximated by a Lennard-Jones and Devonshire-type function appropriate to the given number of neighbors. The equation of state is obtained from the partition function and expressed in terms of a reduced volume and temperature, a cell size parameter and known physical constants. Possible extensions of the present theory are discussed. Author, abridged

515. Theory of vibrational relaxation in liquids. R. ZWANZIG, *J. Chem. Phys.*, 1961, **34**, 1931. National Bureau of Standards, Washington, D.C. A new formulation of the theory of vibrational relaxation, based on Zener's semiclassical approximation, is presented here. The relaxation rate is shown to be proportional to the spectral density of the force exerted on the oscillator by its environment. The isolated binary collision theory is derived, but only with the condition that the collision frequency is much smaller than the oscillator frequency. This requirement is not satisfied in a liquid; we conclude that Litovitz's application of the isolated binary collision theory to liquids is not justified. A possible relation between vibrational relaxation and the self-diffusion coefficient in a liquid is discussed. Author

516. Extrusion of visco-plastic dispersed masses between plane parallel walls. A. M. GUTKIN, *Kolloidnyi Zh.*, 1961, **23**, 20. Department of Physics, Moscow Thermodynamics Institute. A discussion has been made of dually-directed shear of a viscoplastic medium. Equations have been obtained for the flow of a medium in a flat capillary and for the flow rate of one of its walls as a function of the state of stress of the

SECTION A

medium. The equations have been applied also for the case of the extrusion of a viscoplastic medium through the intervening space of a viscometer with rotating coaxial cylinders. [Russian, English abstract]

Author

517. A quantitative theory of the loss of strength by regenerated cellulose filaments on hydrolysis by acid. R. J. E. CUMBERBIRCH and C. MACK, *J. Text. Inst.*, 1961, **51**, T382. The Cotton, Silk and Man-made Fibres Research Association, Shirley Institute, Didsbury, Manchester 20. A model structure for regenerated cellulose that was proposed in an earlier paper is used to account in a quantitative way for the rate of loss of strength of cellulose filaments on hydrolysis by acid. A comparison between theoretical and observed values of loss in strength resulting from acid hydrolysis shows the two sets of values to be in good agreement.

Authors

518. Some properties of continuous-filament yarn. WITOLD ŻUREK, *Text. Res. J.*, 1961, **31**, 504. Politechnika Łódzka Katedra Surowców, Włókienniczych i Metrologii, Łódź, Poland. Theoretical formulae for the retraction, strength and breaking extension of a yarn based on the hypothesis (1) that the fibres when twisted into a yarn change their slope, but no stresses or strains occur in them, and (2) that the fibres are strained in proportion to their distance from the yarn axis, are derived and compared. The equations for yarn retraction are very similar and are identical for yarn strength. Those for elongation at break indicate some difference. It is concluded that migration of the fibres does not influence significantly the properties mentioned above, and that the assumption of helical paths for the fibre axes as a basis for theoretical calculations is valid.

N.W.

519. The in-plane elastic constants of paper. J. G. CAMPBELL, *Aust. J. Appl. Sci.*, 1961, **12**, 356-357. Australian Paper Manufacturers Ltd., G.P.O. Box 1643, Melbourne. The in-plane shear modulus can be calculated from the in-plane values of Young's modulus and Poisson's ratio.

E.R.B.

520. Construction of the equivalent electric circuit from a force circuit diagram by a simple graphical method. N. W. TSCHOEGL, *Aust. J. Phys.*, 1961, **14**, 307-309. Bread Research Institute of Australia, North Ryde, N.S.W.

521. A generalization of Thévenin's theorem. H. K. MESSERLE, *Aust. J. Appl. Sci.*, 1961, **12**, 265-273. School of Electrical Engineering, University of Sydney. Thévenin's theorem provides a means of determining load characteristics of a system without knowing much about the system itself. The theorem has been primarily used in network theory and it is shown here how it can be generalized to apply to any linear or linearized physical system.

Author

VOL.
4
1961

Section B

INSTRUMENTS AND TECHNIQUES

522. Tensile testing machine for whiskers. H. B. M. WOLTERS and F. W. SCHAPINK, *J. Sci. Instrum.*, 1961, 38, 250. Koninklijke/Shell-Laboratorium, Amsterdam, Netherlands. A screw-driven micro-tensile tester for whiskers is described. Authors

523. Micro-tensile testing machine. D. M. MARSH, *J. Sci. Instrum.*, 1961, 38, 229-234. Tube Investments Research Labs., Hinxton Hall, Cambridge. This paper describes a tensile testing machine for microscopic specimens. The machine employs a torsion balance to apply the loads and a mirror auto-collimating telescope system to detect the extensions. Since it depends wholly on mechanical and optical principles it is practically drift-free at constant temperature. It is adaptable for tests in special atmospheres, for autographic recording, and for tensile testing of thin films. The machine can apply loads from 1 mgf to 400 gf to specimens having cross-sectional areas down to 10^{-7} mm². Specimen extensions from 5 Å to 15 mm can be measured. Author

524. Rotational vibroscope for the comparison of the torsional properties of thin fibres. P. NORDON, *J. Sci. Instrum.*, 1961, 38, 349-351. C.S.I.R.O. Wool Research Laboratories, Division of Textile Physics, Sydney, Australia. An apparatus is described for the measurement of the dynamic torsional properties of textile fibres in the frequency range of 1 to 200 c/s, using forced oscillations. The apparatus is particularly suitable for following the kinetics of the change in torsional properties caused by changes in temperature and/or humidity of the air surrounding the test specimen. Author

525. A method of measuring the stress relaxation of soft materials by electronic control. T. UEMATU, *J. Japan Soc. Test. Matls.*, May, 1961, 53-54. Faculty of Liberal Arts, Saga University, Saga. Soft materials can be deformed electromagnetically with a certain driving device through which the anode current flows. The deformation is transformed to electric signal voltage by a transducer and detector circuit, that is Inoue's circuit. This signal voltage, after being amplified, controls the grid voltage of the triode degeneratively. The anode current varies in connection with stress relaxation so as to keep variation of deformation very low in amount by the degenerative action of the feedback loop including the triode, the driving device, the detector and the amplifier. The strain is held almost constant during stress relaxation. As the device produces a force proportional to the anode current, the variation of stress can be observed by measuring the anode current variation. [Japanese, English summary] Author, abridged

526. Measurement of the modulus of dynamic elasticity of staple fibers. H. G. WEYLAND, *Text. Res. J.*, 1961, 31, 629. Central Research Institute of A.K.U. and Affiliated Companies, Arnhem, Holland. A description

SECTION B

is given of an apparatus with the aid of which the modulus of dynamic elasticity of fibers can be determined at about 1000 c/s as a function of strain. In principle the dynamic elasticity constant of the fiber is determined by measuring the resonance frequency of a cantilever spring which is loaded with the fiber. The results of measurements on various types of natural, regenerated, and synthetic fibers are given. Author

527. A new apparatus for measuring the viscoelasticity of solid polymers. E. FUKADA and M. DATE, *J. Japan Soc. Test. Mats.*, May, 1961, 49-52. Kobayashi Institute of Physical Research, Kokubunji, Tokyo. An apparatus is described for measuring the dynamic properties of polymers over the ranges 0.01 to 20 cycles/s., 20° to 160°C, and 10^7 to 10^{11} dynes/cm² dynamic Young's Modulus. Forced vibrations are used. The properties of polyvinylacetate-styrene graft co-polymers were studied over the available range. [Japanese, English summary]

Authors, abridged

528. Twin transducers for measuring the complex shear modulus of polymers at audio-frequencies. E. FUKADA, A. ODA, M. OHIRA, S. OGAWA, S. OKUAKI and H. OBATA, *J. Japan Soc. Test. Mats.*, May, 1961, 42. Kobayashi Institute of Physical Research, Kokubunji, Tokyo. A new design of electromagnet transducer, for use in a Fitzgerald type apparatus, is described. The plot of electrical transfer impedance is smooth over the range 50 to 8000 cycles/s. This enables resonance dispersion in crystalline polymers to be detected, free from instrument effects, in this range. The transducer constant K^2 is 1.1×10^5 ohms. dynes. sec./cm. [Japanese, English summary]

Authors, abridged

529. Calculation of the energy loss in a hysteresis loop for non-linear stressing. G. KEMMNITZ, *Faserforschung*, 1961, 12, 289. Glanzstoff-Courtaulds GmbH, Köln, W. Germany. The energy loss of the hysteresis loop of tire cords is calculated separately for the loading and the unloading part of the cycle. The sum of these energies then yields the total energy loss per cycle. The method is suitable for linear and non-linear stressing, the latter being defined as occurring whenever the hysteresis loop deviates from the elliptical shape. For non-linear stressing the phase angle is assumed to be composed of a constant and a time dependent component which is given the physical interpretation of a non-linear relaxation. Two examples are given to show that this approach gives useful approximations of the area of the hysteresis loop when compared with planimetered values. [German, English abstract]

G.R.

530. A rheometer for measuring the viscoelasticity of high polymer melts. M. HORIO, S. ONOGI and S. OGIWARA, *J. Japan Soc. Test. Mats.*, May, 1961, 55-58. Department of Polymer Chemistry, Kyoto University, Kyoto. A recording rheometer is described, which can be used as a Couette type viscometer, an oscillating rheometer or a forced vibration torsion pendulum. A differential transformer device is used to detect displacement of one or both cylinders. The frequency range available

INSTRUMENTS AND TECHNIQUES

is from 1/256 to 8 cycles/s. and the speed range from 0.122 to 240 rev./min. The dynamic properties of polyethylene were studied at 200°C. The dynamic viscosity as a function of angular frequency coincides with the apparent viscosity as a function of rate of shear. [Japanese, English summary] Authors, abridged

531. An experimental determination of the detailed distortion in hot rolling. B. E. MILSOM and J. M. ALEXANDER, *J. Mech. Phys. Solids*, 1961, 9, 105. Department of Mechanical Engineering, Imperial College, London. A technique has been developed for measuring the detailed distortion occurring in the arc of contact of a rolling mill under conditions simulating hot rolling.

532. Coaxial cylinder viscometer for non-Newtonian fluids. JOHN C. HARPER, *Rev. Sci. Instrum.*, 1961, 32, 425-428. Department of Agricultural Engineering, University of California, Davis, California. A full description is given of a coaxial cylinder viscometer, including mechanical details of construction, which satisfies the following conditions: (a) speed of rotation automatically variable between zero and maximum, (b) non-rotating cylinder fully damped, (c) automatic recording of curves of torque vs. speed and torque vs. time at constant speed, (d) alternative cylinders of several gap widths, (e) gap width not greater than 10 per cent. of radius, (f) sample can be introduced continuously while viscometer is working. J.O.C.

533. A bar viscometer with conical annulus. D. TOLLENAAR, *J. Colloid Sci.*, 1960, 15, 381-383. In the viscometer described, a cylindrical rod falls through a slightly wider annulus in which the liquid is contained. The annulus has a conical bore to ensure better centering of the bar. High shear stresses can be obtained easily without serious rise in temperature. The formula for the rate of fall is given. D.D.

534. Methods for investigating the frictional properties under the influence of strong unidirectional compression. B. V. DERYAGIN and YU. P. TOPOROV, *Kolloidnyi Zh.*, 1961, 23, 118. Institute of Physical Chemistry, Acad. Scis. U.S.S.R., Moscow. Methods of investigating the frictional properties of polymeric materials under conditions of unidirectional compression have been described. Diagrams of two simple devices have been presented, permitting the static friction of polymer specimens to be measured at specific compression loads up to 1000 kg/cm². [Russian, English abstract] Authors

535. Two-transistor oscillator for displacement measurements. L. M. TRÉMOUROUX, *J. Sci. Instrum.*, 1961, 38, 259. European Research Associates, 95 rue Gatti de Gamond, Brussels 18, Belgium. The variations in capacitance, due to displacement of a transducer capacitor, may be measured by making the capacitor part of the LC circuit of an oscillator and by following the corresponding changes in frequency. W.G.C.

SECTION B

536. A method for gauge factor determination. I. G. SCOTT, *J. Sci. Instrum.*, 1961, 38, 291-293. Australian Defence Scientific Service, Aeronautical Research Labs., Department of Supply, Melbourne, Australia. A simple device for the determination of gauge factor of electrical resistance strain gauges is described. Author

Section C

METALS AND OTHER SOLIDS

537. Quick-sand like properties and thixotropy of dispersed sedimentary rocks. I. M. GORKOVA, *Kolloidnyi Zh.*, 1961, 23, 12. Lab. for Hydrogeological Problems, Acad. Scis., U.S.S.R., Moscow. [Russian, English abstract]

538. Minimum energy theorem for flow of dry granules through apertures. R. L. BROWN, *Nature, Lond.*, 1961, 191, 458-461. British Coal Utilisation Research Association, Leatherhead, Surrey. A theoretical equation is derived for the flow of granules through an aperture in the base of a vessel. Satisfactory agreement is obtained between the theoretical curve and the experimental data using such material as glass beads, tapioca, coal and various sands. W.G.C.

539. Influence of moisture changes on deformation of wood under stress. L. D. ARMSTRONG and G. N. CHRISTENSEN, *Nature, Lond.*, 1961, 191, 869-870. Division of Forest Products, C.S.I.R.O., Melbourne, Australia. Bending experiments were carried out on wood beams with dimensions $90 \times 2 \times 2$ cm., and $60 \times 1 \times 1$ mm. The results confirm that when wood is subjected to a sustained bending load, a change in moisture content affects the rate and magnitude of deformation. Most of the change in deformation occurs within the period during which the moisture content change takes place. Its magnitude depends mainly on the extent, rather than the rate, of moisture content change. Explanations are suggested for the observed behaviour. W.G.C.

540. Swelling pressure of wood. D. NARAYANAMURTI and R. C. GUPTA, *J. Japan Soc. Test. Matls.*, May, 1961, 139-143. Forest Research Institute, Dehra Dun, India. The swelling pressures developed in 80 species of wood, including an acacia 30,000 years old, were measured on a stress relaxation apparatus. Swelling pressure affords a valuable criterion for following dimensional stabilisation. J.H.C.V.

541. Some aspects of the rheological behaviour of wood. I. The effect of stress with particular reference to creep. R. S. T. KINGSTON and L. N. CLARKE, *Aust. J. Appl. Sci.*, 1961, 12, 211-226. Division of Forest Products, C.S.I.R.O., Melbourne. Some aspects of the rheological behaviour of air-dry wood of two eucalypts and of hoop pine were studied at stresses from 15 to 85% of the short time ultimate strength. Creep and relaxation tests were carried out in bending, stress-strain

relationships were determined in shear and some creep tests on hoop pine were done in shear. At 21.5°C the relationship between creep deformation and stress was found to depart from linearity at stresses above about 40% of the ultimate strength. Both recoverable and irrecoverable creep increased considerably with increasing temperature. Creep in hoop pine in shear was found to be greater than in bending at similar proportions of the ultimate strength. The increase in relaxation was found to be quite marked when the strain was increased above about 80% of its ultimate value. The effect of rate of loading on the stress-strain curve was found to be small within the range of times used. The different species did not in general show widely different behaviour except that for blackbutt the non-linearity was not appreciable.

Authors, abridged

542. Some aspects of the rheological behaviour of wood. II. Analysis of creep data by reaction rate and thermodynamic methods. R. S. T. KINGSTON and L. N. CLARKE, *Aust. J. Appl. Sci.*, 1961, **12**, 227-240. Division of Forest Products, C.S.I.R.O., Melbourne. Data on creep in wood given in the previous paper are analysed here. The variation in creep compliance with stress is discussed. Reaction-rate analyses were made on the data, using the Eyring hyperbolic sine law for recoverable creep in conjunction with a three-element model and assuming that, over the short times used with high stresses, the irrecoverable flow rate was constant. In general, the data fitted this law reasonably well. Rate constants and activation energies are given for all species tested under creep conditions. From the results, an attempt has been made to form a preliminary hypothesis of the molecular nature of recoverable creep. The intrinsic energy and entropy components of free energy have been discussed and the implications of the results briefly outlined.

Authors, abridged

543. Studies of the behaviour of textile fabrics at various temperature and humidity conditions. H. SOMMER and H. VIETH, *Faserforschung*, 1961, **12**, 309. Deutsche Akademie der Wissenschaften, Berlin. The bursting strength of sixteen fabrics of different natural and man-made fibres was tested at three temperatures (10°, 20° and 35°C) and a range of humidities (35% to 90% R.H.). In this region log-log plots of bursting strength versus the humidity deficit (i.e. 100-R.H.%) gave straight lines, the slopes of which give the moisture sensitivity of the fibre. [German, English abstract]

G.R.

544. Macroscopic properties and microscopic structure in paper. M. LITT, *J. Colloid Sci.*, 1961, **16**, 297. Chemistry Department, State College of Forestry at Syracuse University, Syracuse, New York. A theory of paper elasticity was developed considering that paper fibers were flat ribbons joined to many other fibers by hydrogen bonds. When paper was stressed, the force was equalized for each interfiber bond without regard for the orientation of the fiber, and the fiber segments between bonds were distorted in the direction of the force. An analysis of literature experimental results shows that this theory can explain

SECTION C

Young's modulus for paper. The theory was tentatively extended to discuss Poisson's ratio and, qualitatively, plastic flow behaviour.

Author

545. Properties of stressed bone. H. M. PEARSON, *Nature, Lond.*, 1961, **190**, 1217. British Transport Commission, 222 Marylebone Road, London, N.W.1. Brief comments on the paper by DREYER, *Rheology Abstracts*, 1961, **4**(2), 220. W.G.C.

546. Properties of stressed bone. C. J. DREYER, *Nature, Lond.*, 1961, **190**, 1217. University of the Witwatersrand, Milner Park, Johannesburg, South Africa. Discusses briefly the points raised by PEARSON (above). W.G.C.

Section D

POLYMERS, ELASTOMERS AND VISCOELASTIC MATERIALS

547. Viscosity of macromolecules. L. ANDRUSSOW, *J. Chim. phys.*, 1960, **57**, 952-958. [French]

548. Structures of high polymers, and their thermomechanical transition points. M. CHATAIN and P. DUBOIS, *C. R. Acad. Sci.*, 1961, **252**, 1141-1143. [French]

549. Viscoelastic behaviour and glass transition of high polymers. T. HIDESHIMA, *J. Japan Soc. Test. Matls.*, May, 1961, 9-19. The Institute of Physical and Chemical Research, Tokyo. The prevailing relaxation theory of the nature of the glass transition point in polymers is re-examined. The glass transition is essentially a non-linear relaxational phenomenon; there is a precipitous change of volume relaxation time or viscosity near the transition temperature. By using a simple first order kinetic equation for volume retardation, and a Doolittle equation for viscosity, it is shown that the WLF equation referred to some equilibrium state implies that the volume follows the equilibrium liquid line. The viscosity deviates from the WLF curve as the temperature is lowered in response to the commencement of volume retardation. The theory is verified by viscoelastic and thermal expansion experiments on polystyrene, perspex, polyethylene, poly-n-propylmethacrylate and a phenol formaldehyde resin. [Japanese, English summary] Author, abridged

550. Comparison of dielectric properties between semi-crystalline and amorphous polymers. M. TAKAYANAGI, Y. ISHIDA and K. YAMAFUJI, *J. Japan Soc. Test. Matls.*, May, 1961, 88-92. Faculty of Engineering, Kyushu University, Fukuoka. The dielectric properties of several amorphous and crystalline polymers are reported. Evidence is put forward suggesting that the α -absorption can be attributed to the re-orientation of the dipoles due to segmental micro-Brownian motion of the

main chains, and the β -absorption to the rotating diffusional motions of the dipoles due to local micro-Brownian motions of the main chains. [Japanese, English summary] Authors, abridged

551. Effect of molecular weight distribution of polymer on stress relaxation spectrum. K. MURAKAMI, *J. Japan Soc. Test. Matls.*, May, 1961, 72-76. Faculty of Engineering, University of Tokyo, Tokyo. An attempt is made to relate quantitatively the distribution of mechanical relaxation times and the molecular weight distribution of linear amorphous polymers. [Japanese, English summary] J.H.C.V.

552. Proton magnetic resonance of some poly-(α -olefins) and α -olefin monomers. A. E. WOODWARD, A. ODAJIMA and J. A. SAUER, *J. Phys. Chem.*, 1961, **65**, 1384. Department of Physics, The Pennsylvania State University, University Park, Pa. Proton magnetic resonance spectra of a series of polyolefins and some of their monomers have been obtained from 77 to 300°K or higher. Line narrowing and second moment changes are associated with changes in molecular mobility. Comparison with dynamic mechanical measurements on the same samples at frequencies of 500-2000 cp.s. shows that the transition regions are essentially at the same temperature by both types of measurement. I.H.H.

553. Normal stresses in solutions of polyisobutylene from elastic deformation and tangential force data. A. A. TRAPEZNIKOV, *Kolloidnyi Zh.*, 1961, **23**, 125. Inst. of Phys. Chem., Acad. Scis., Moscow. Normal stresses in 20% polyisobutylene solution calculated from experimental data on elastic deformation and shearing force pass through a maximum on increasing the predetermined deformation from rest to steady state flow. Owing to the noncoincidence of the maxima for the two latter quantities the normal stress maximum is shifted towards larger deformations in comparison with the maximum tangential force. This may explain the experimental results obtained earlier on other systems. [Russian, English abstract] Author

554. Mechanical properties of Ziegler's polyethylene. J. MAJER, *Chem. primysl*, 1961, **11**, 153-156. [Czech, English summary]

555. Role of chain branchings in flow behaviour of polyethylene. S. IWAYANAGI, *J. Japan Soc. Test. Matls.*, May, 1961, 61. The Institute of Physical and Chemical Research, Tokyo. The melt viscosity of high pressure (branched) polyethylene is much smaller than that of low pressure (linear) polyethylene of the same molecular weight. This has previously been interpreted as due to the effect of the side chains on free volume. The author considers that free volume is unlikely to affect viscosity to such an extent at temperatures 150°C above the glass transition temperature, and suggests that the phenomenon is an activation energy effect. Melt viscosity measurements on a range of polyethylenes at a series of temperatures support this suggestion to some extent. [Japanese, English summary] Author, abridged

SECTION D

556. Fine structure and viscoelastic absorption of crystalline high polymers. M. TAKAYANAGI, M. YOSHINO and K. HOASHI, *J. Japan Soc. Test. Matls.*, May, 1961, 123-128. Faculty of Engineering, Kyushu University, Fukuoka. Locations of absorption maxima of crystalline polymers are interpreted in terms of their crystalline structure. A series model of crystalline (C) and amorphous (A) regions corresponds to the fringed micelle model adopted for such materials, in which an applied stress is transferred from the crystalline to the amorphous region along molecular chains. For the AC series model, only one absorption maximum exists between the two maxima corresponding to pure crystalline and pure amorphous regions. On the other hand, with a spherulitic texture with lamella structure, an AC parallel model is required, since the lamella forms a continuous crystalline phase. Such a system has two intermediate maxima. A series of polyethylene and polyethylene terephthalate samples was examined and it was found that AC parallel behaviour was applicable in all cases; the behaviour is retained after drawing. [Japanese, English summary] Authors, abridged

557. Dependence of the tensile properties of polyethylene on strain rate and temperature. T. KAWAGUCHI, *J. Japan Soc. Test. Matls.*, May, 1961, 99-102. Central Research Laboratory, Tokyo Rayon Co., Ltd., Otsu. The effect of strain rate on the ultimate strain, tensile strength, yield strength and modulus of drawn polyethylene filament was studied over the range 10 to 1000%/min. and 0° to 80°C. The time temperature superposition method was extended to take account of crystallinity. [Japanese, English summary] Author, abridged

558. Viscoelastic behaviour of crosslinked polyethylene. Y. UEMATSU and E. FUKADA, *J. Japan Soc. Test. Matls.*, May, 1961, 96-98. Kobayashi Institute of Physical Research, Kokubunji, Tokyo. The effect of extension on the viscoelastic behaviour and on the temperature of incipient crystallisation was studied for irradiated polythene film. [Japanese, English summary] J.H.C.V.

559. Dynamic mechanical studies of irradiated polyethylene. L. J. MERRILL, J. A. SAUER and A. E. WOODWARD, *Polymer*, 1960, 1, 351-364. Department of Physics, Pennsylvania State University, U.S.A. The dynamic mechanical properties of high density polyethylene irradiated in a ⁶⁰Co source at dosages of 10⁸-10⁹ r.e.p. have been investigated from 80°K to 450°K at audiofrequencies using a resonance technique. With increasing radiation dose the slope of the modulus v. temperature relation above the melting temperature, 410°K, increases, indicating an increasing degree of crosslinking of the network structure. The damping peak in the 390°K region is also observed to decrease in magnitude. At gamma-ray doses of 6 × 10⁸-10⁹ r.e.p. the crosslinking efficiency is found to be somewhat greater for the high density polyethylene than for a low density polyethylene irradiated at room temperature under similar conditions. The effect of a subsequent heat treating and annealing operation has been studied for both low and high density polyethylene and for both ⁶⁰Co irradiation and pile irradiation. Authors, abridged

560. Stress-temperature coefficients of polymer networks and the conformational energy of polymer chains. A. CIFERRI, C. A. J. HOLVE and P. J. FLORY, *J. Amer. Chem. Soc.*, 1961, **83**, 1015-1022. Mellon Institute, Pittsburg, Pa. Stress-temperature coefficients are reported for cross linked polythene and polyisobutylene elongated in the amorphous state. Results are considered in relation to theories of rubber elasticity.

W.H.B.

561. Viscoelastic properties of polypropylene. I. UEMATSU and Y. UEMATSU, *J. Japan Soc. Test. Matls.*, May, 1961, 93-95. Tokyo Institute of Technology, Tokyo. The degree of crystallinity of a series of samples of polypropylene was determined from specific volume measurements, and compared with the dynamic mechanical properties of such materials. It is shown that the logarithm of the dynamic modulus is a linear inverse function of specific volume, irrespective of the thermal condition of the sample used. [Japanese, English summary] Authors, abridged

562. Definition and application of constants A and B determined by procedure X. K. MURAKAMI, *J. Japan Soc. Test. Matls.*, May, 1961, 116-122. Faculty of Engineering, Tokyo University, Tokyo. Procedure X is a method of calculating a value of the maximum relaxation time of a linear amorphous polymer from mechanical property results (A. V. TOBOLSKY and K. MURAKAMI, *J. Colloid Sci.*, 1960, **15**, 282). The system is evaluated on a series of monodisperse and polydisperse polystyrene samples. [Japanese, English summary] Author, abridged

563. Mechanical behaviour of swollen polystyrene, poly-(p-chlorostyrene) and their copolymers in benzene. Part 2. Stress relaxation under constant strain. K. OGINO, *Bull. Chem. Soc. Japan*, 1961, **34**, 153-157.

564. Synthesis and mechanical properties of isotactic polystyrene. V. A. KARGIN, V. A. KABANOV and I. IU MARCHENKO, *Polymer Sci. USSR*, 1960, **1**, 41-51. Faculty of Chemistry, Lomonosov State University, Moscow.

565. Changes in stress-strain properties of natural rubber vulcanizates during ageing. J. R. DUNN and J. SCANLAN, *Trans. Faraday Soc.*, 1961, **57**, 160-166. The Natural Rubber Producers' Research Association, Welwyn Garden City, Herts. Stress-strain measurements have been made at intervals during the ageing of a peroxide vulcanizate and a sulphenamide-accelerated sulphur vulcanizate of natural rubber. The results are explained by the oxidative scission of polymer chains. In the case of the sulphur vulcanizate, scission occurs possibly at the cross links and is accompanied by the formation of additional cross links.

W.H.B.

566. The effect of deformation on the transition rubber-glass. GEOFFREY GEE, P. N. HARTLEY, J. B. M. HERBERT and H. A. LANCELEY, *Polymer*, 1960, **1**, 365-374. Department of Chemistry, University of Manchester, England. The nature of the transition is discussed and a thermodynamic

SECTION D

treatment is applied to calculate the effect of elongation on the transition temperature. A dilatometric technique for the measurement of the transition temperature is described which yields reproducible results for stretched rubbers. The agreement between the calculated and experimental results indicates that the application of a thermodynamic treatment to the rubber-glass transition, measured in this way, is justified.

Authors

567. Mechanical behaviour of SBR in Mooney viscometer. K. NINOMIYA, *J. Japan Soc. Test. Matls.*, May, 1961, 81-83. Yokkaichi Copolymer Plant, Japan Synthetic Rubber Co., Ltd., Yokkaichi. Equations are presented describing the behaviour of SBR samples, of molecular weights ranging from 1×10^5 to 6×10^5 at 100°C , under steady shearing rates, and on stress relaxation. Both sets of equations contain a constant, considered to be the stored elastic energy in the sample after a considerable time at the stationary flow rate. A second parameter is used in the description of steady shearing, or stress relaxation, behaviour, when the sample has not been sheared long enough for the steady state to be reached. [Japanese, English summary] Author, abridged

568. The molecular structure and mechanical properties of polyethylene terephthalate fibers. I. M. WARD, *Text. Res. J.*, 1961, 31, 650. I.C.I. Ltd., Fibres Division, Hookstone Road, Harrogate, Yorkshire, England. In this paper, the application of several techniques of molecular structure determination to polyethylene terephthalate (henceforth abbreviated to PET) polymer and fibers will be described. These investigations have been directed partly towards obtaining an understanding of the dynamic mechanical properties of PET and related polymers, and partly to the characterization of PET fibers with respect to crystallinity and orientation. In considering the dynamic mechanical properties of PET and their relationship to the molecular structure two main points have been investigated; first whether the dynamic mechanical transitions can be related to specific motions of the molecular chains, and second whether the influence of crystallinity and orientation can be simply understood.

Author

569. Crystallisation kinetics in polyvinyl chloride and thermoelastic relaxation induced by ultrasonics. V. NARDI, *Nature, Lond.*, 1961, 191, 563-565. Istituto Nazionale di Fisica Nucleare, Istituto di Fisica dell'Università, Padova, Italy. The proportion of crystalline material in polyvinyl chloride has been increased by radiation with 1 Mc/s ultrasonics. The effect on the mechanical and thermoelastic properties of PVC has been observed.

W.G.C.

570. Mechanical and dielectric properties of the homogeneous and heterogeneous polymer blends. T. TABATA, *J. Japan Soc. Test. Matls.*, May, 1961, 112-115. Optical and electron microscope studies are reported on PVC-Hycar and PVC-polyethylene systems. The former was a homogeneous mix, the latter remained heterogeneous. Mechanical and dielectric data for these systems are compared in the light of this difference. [Japanese, English summary] J.H.C.V.

571. The analysis of hot drawing mechanism. K. KAWAI, T. AKIYAMA and K. AKABANE, *J. Japan Soc. Test. Matls.*, May, 1961, 129-132. Research Laboratory, Kurashiki Rayon Co., Ltd., Okayama. The relation between draw ratio, time, temperature and draw tension is described and discussed for polyvinylacetate filament yarn. [Japanese, English summary] J.H.C.V.

572. Tensile stress relaxation behaviour of partly to highly formalised polyvinyl alcohol polymers. K. FUJINO, K. SENSU and H. KAWAI, *J. Japan Soc. Test. Matls.*, May, 1961, 84-87. Department of Polymer Chemistry, Kyoto University, Kyoto. Stress relaxation studies are reported for a series of polyvinyl alcohol polymers reacted with formaldehyde, over the range 10 to 7000 seconds and 80° to 160°C. The temperature dependence of the shift factor cannot be expressed by the simple WLF equation, but must be expressed by a combination of at least two WLF type equations. The temperature dependence of apparent activation energy shows not only the expected maximum at the glass transition temperature, but another small maximum at a higher temperature. These two anomalies are shown to be interrelated. [Japanese, English summary] J.H.C.V.

573. Stress relaxation of thermo-reversible gels: molecular-weight dependence of relation spectrum of poly(vinyl alcohol)-Congo Red-water system. K. ARAKAWA, *Bull. Chem. Soc. Japan*, 1960, 33, 1568-1571.

574. The dielectric and dynamic mechanical properties of the phenol resin-polyvinyl butyral mixed coating films. Y. TAKAHASHI, *J. Japan Soc. Test. Matls.*, May, 1961, 103-111. Hokkai Can Mfg. Co., Ltd., Otaru. Dielectric measurements on the phenol resin-polyvinylbutyral system are reported over the range -70 to +170°C and 0.3 to 10⁶ cycles/s., and dynamic mechanical property measurements over the range -70 to +200°C at 50 cycles/s. In the high temperature region, increase of PVB content lowers the temperature of the loss maximum and lowers the apparent activation energy of dielectric absorption. In the low temperature region, the activation energy is independent of composition; only the dielectric relaxation time is affected by changing the PVB content. [Japanese, English summary] J.H.C.V.

575. Compressive creep behaviour of acrylic resin and its temperature dependence. T. ARAI and I. SUZUKI, *J. Japan Soc. Test. Matls.*, May, 1961, 77-80. Tokyo Institute of Technology, Tokyo. The Mooney-Treloar-Rivlin equations for rubber elasticity are found to be valid for the creep behaviour of polymethyl methacrylate. Curves of creep compliance vs. log time for different temperatures can be shifted to superpose. Although this appears to be correlated with standard "reduced variables" concepts, detailed analysis indicates that the reduced variables system is inadequate for complete description of the behaviour, due to thermal effects. [Japanese, English summary]

Authors, abridged

SECTION D

576. Tensile stress relaxation behavior of methylmethacrylate and methacrylate copolymers. K. FUJINO, K. SENSU and H. KAWAI, *J. Colloid Sci.*, 1961, **16**, 262. Department of Textile Chemistry, Kyoto University, Kyoto, Japan. The stress relaxation curves of methylmethacrylate-methacrylate copolymers have been studied at various temperatures. "Master curves" were derived, the relation between "shift factor" a_T and temperature agreeing well with the W.L.F. equation within the temperature range $\pm 50^\circ\text{K}$ about T_s , a distinctive temperature. The shapes of relaxation spectra for these polymers were typical of an amorphous polymer, and varied systematically with increasing mole ratio of MMA. R.W.W.

577. Dynamic mechanical properties and creep of poly-2-ethyl butyl methacrylate. T. P. YIN and J. D. FERRY, *J. Colloid Sci.*, 1961, **16**, 166. Department of Chemistry, University of Wisconsin, Madison, Wisconsin. The real and imaginary components of the complex compliance have been measured between 0.05 and 3600 cycles/sec. in the temperature range from 20° to 151°C for a fractionated poly-2-ethyl butyl methacrylate with molecular weight 2.20×10^5 . The creep compliance, and creep recovery were measured from 101° to 151°C . The glass transition temperature was determined to be 11°C . The method of reduced variables gave superposed curves in the transition zone with shift factors following the WLF form of equation; the WLF parameters were $f_g = 0.021$, $a_f = 1.8 \times 10^{-4} \text{ deg.}^{-1}$. In the plateau zone (including the creep) an additional f -reduction for temperature dependence of entanglement was necessary. In general, the viscoelastic behavior of the 2-ethyl butyl polymer resembles that of the n -butyl much more closely than that of the n -hexyl which has the same side chain molecular weight.

578. Mechanical properties of poly-(2-ethylbutyl methacrylate) and poly(ethylene oxide). T. PENG-JUNG YIN, *Diss. Abs.*, 1960, **21**, 1396.

579. Dielectric properties of methacrylic ester polymers. M. TAKAYANAGI, Y. ISHIDA, K. YAMAFUJI and O. AMANO, *J. Japan Soc. Test. Matls.*, May, 1961, 66-71. Faculty of Engineering, Kyushu University, Fukuoka. The frequency dependence of dynamic mechanical properties has been measured for a series of methacrylates, including polymethyl, polyethyl, polybutyl, polyisobutyl, polycyclohexyl and polynonyl. The variation of shape and size of the α - and β -absorptions of the different polymers was studied. The one with the loosest packing (polynonyl methacrylate) has the lowest activation energy for the α -absorption; the β -absorptions show little difference in activation energy. [Japanese, English summary] Authors, abridged

580. Thermo-mechanical properties of plasticized ethyl cellulose. D. I. GALPERIN, V. V. MOSHEV and V. G. STEPANOVA, *Kolloidnyi Zh.*, 1961, **23**, 8. The temperature dependence of the plastic and high elastic properties of an ethylcellulose plastic containing 25% dibutylphthalate has been studied. It has been shown that the plastic, like other polymers, undergoes stress softening, i.e. manifests forced elastic properties below the glass temperature and irreversible flow properties below the flow

temperature. The stress softening is due to the effect of the shearing stress on the activation energy, resulting in a reduction of the relaxation times and micro- and macroviscosity coefficients. [Russian, English abstract]
Authors

581. The dielectric and dynamic mechanical properties of polyoxymethylene (Delrin). B. E. READ and G. WILLIAMS, *Polymer*, 1961, 2, 239-255. National Physical Laboratory, Teddington, Middlesex. The dielectric and dynamic mechanical properties of polyoxymethylene (Delrin) have been measured in order to investigate molecular motions in this polymer. The dynamic shear modulus and loss factor have been determined in the frequency range from 0.05 to 1 c/s. from -190°C up to the melting point (180°C). Two loss maxima have been observed at about -77°C and 87°C respectively. The dielectric properties have been investigated over the frequency range 120 c/s. to 9 kMc/s. and the temperature range -80°C to $+150^{\circ}\text{C}$. A single broad relaxation absorption was observed which correlates with the low temperature mechanical relaxation. The effect on these relaxations of swelling the polymer with dioxan is consistent with motions occurring in the amorphous regions of the polymer only.
Authors

582. Rheological properties of molecules in Dacron fibre. Pt. 2. Rheological properties of molecules in Nylon 66 fibre. Pt. 3. Statistical thermodynamical theory of surface tension. S. CHANG, *Diss. Abs.*, 1961, 21, 2501.

583. Viscoelastic dispersion of polydimethyl siloxane in the rubber-like plateau zone. D. J. PLAZEK, W. DANNHAUSER and J. D. FERRY, *J. Colloid Sci.*, 1961, 16, 101. Department of Chemistry, University of Wisconsin, Madison, Wisconsin. The viscoelastic properties of six stocks of polydimethyl siloxane, with molecular weights ranging from 0.41 to 4.9×10^5 , have been studied by dynamic and creep methods, between -49° and 75°C . and from a maximum frequency of 600 cycles/sec. to a maximum time of 36 days. The methods included the Fitzgerald transducer, Morrisson-DeWitt forced oscillation torsion pendulum, Plazek freely oscillating torsion pendulum, and creep and creep recovery in torsion and in simple shear. All dynamic measurements at different temperatures were successfully superposed by the method of reduced variables with shift factors calculated from the viscosity temperature dependence. The results suggest the presence of a quasi-permanent network intermediate in character between chemically cross-linked and entanglement networks, the linkages of which yield when a critical strain has been exceeded.

584. Conformational energy of chain molecules. Part I—Tension temperature coefficient for polydimethylsiloxane networks. A. CIFERRI, *Trans. Faraday Soc.*, 1961, 57, 846-853. Chemstrand Research Center, Inc., Durham, N. Carolina. Tension/temperature measurements are reported on samples of silicone rubber at constant length over the range 290° – 370°K .
W.H.B.

SECTION D

585. Conformational energy of chain molecules. Part II. Intrinsic viscosity-temperature coefficient for athermal polydimethylsiloxane solutions. A. CIERRI, *Trans. Faraday Soc.*, 1961, **57**, 853-858. Chemstrand Research Center, Inc., Durham, N. Carolina. Intrinsic viscosities of a high molecular weight dimethylsiloxane polymer have been measured, as a function of temperature, in different low molecular weight polydimethylsiloxane oils. W.H.B.

586. Nuclear magnetic resonance study of some liquid-containing poly-(hexamethylene adipamides). R. P. GUPTA, *J. Phys. Chem.*, 1961, **65**, 1128. Department of Physics, The Pennsylvania State University, University Park, Pa. Nuclear magnetic resonance study of poly-(hexamethylene adipamide) containing various liquids has been done to determine their effect on molecular motion in the polymer. Two main transitions have been observed for the soaked samples, one about 160°K, the other about 270°K. For the dry specimen the main transition appears at about 350°K. The second moment of the dry specimen is lower than the second moment for the soaked samples, below the first transition temperature. These features are associated with changes in molecular mobility. I.H.H.

587. Stress-strain relationships in yarns subjected to rapid impact loading. Part VII. Stress-strain curves and breaking-energy data for textile yarns. JACK C. SMITH, PAUL J. SHOUSE, JOSEPHINE M. BLANDFORD and KATHRYN M. TOWNE, *Text. Res. J.*, 1961, **31**, 721. National Bureau of Standards, Washington 25, D.C. Stress-strain curves at rates of straining up to 440,000%/min. have been obtained for a number of textile yarns by a technique involving high speed photography of the yarn following transverse impact. These curves and others obtained at conventional speeds are presented for samples of acetate, triacetate, cotton, polyester, glass fiber, human hair, vinal, nylon, acrylic, rayon, saran, and silk yarns. Also given are specific breaking energies obtained from the areas under the stress-strain curves and by direct measurements involving longitudinal impact speeds of the order of 50 m/sec. These data show how stress-strain curves depend upon rate of straining and provide ratings for the yarns with respect to ability to survive impact and to resist impact without appreciable deformation. Authors

588. Melting equilibrium for collagen fibres under stress. Elasticity in the amorphous state. P. J. FLORY and O. K. SPURR, *J. Amer. Chem. Soc.*, 1961, **83**, 1308-1316. Department of Chemistry, Cornell University, Ithaca, New York. The relationship between the tensile force and the melting temperature (T_m) for rat tail tendon collagen cross linked with *p*-benzo-quinone was studied in pure water and in 1M. and 3M. KCNS. At temperature above T_m , the stress for shrunken material maintained at fixed elongation is approximately proportional to the absolute temperature. The elasticity is rubber like. W.H.B.

589. The effect of moisture sorption on the dynamic mechanical properties of textile fibers. K. SHIRAKASHI, K. ISHIKAWA and M. SEGAWA, *J. Japan Soc. Test. Matls.*, May, 1961, 133-138. Department of Textile

VOL.
4
1961

Engineering, Tokyo Institute of Technology, Tokyo. The relation between dynamic mechanical properties and recovery behaviour of textile fibres (Fortisan, high tenacity rayon, viscose rayon, nylon, acetate) and humidity was studied. It is suggested that the effect of water is to break hydrogen bonds; using the relation:—

$$n = k E^2$$

where n is the number of hydrogen bonds in unit volume, E is the modulus, and k is a constant, it is shown that the effect of water on the modulus is of the expected order. [Japanese, English summary]

Authors, abridged

Section E

PASTES AND SUSPENSIONS

590. Streaming birefringence of soft linear macromolecules with finite chain length. A. PETERLIN, *Polymer*, 1961, 2, 257–264. Technische Hochschule, Munich, Germany. The change of hydrodynamic interaction with coil expansion in laminar flow together with saturation effects due to finite chain length influences the streaming birefringence. The latter initially has values obtained by the former theories with zero gradient interaction parameters. The further increase in birefringence and deviation of extinction angle from 45° with increasing gradient, however, is slower. The shorter the chain, the faster the birefringence approaches saturation. The effect of finite chain length on extinction angle, however, is very small. Author

591. Interpretation of viscosity data for concentrated polymer solutions. H. FUJITA and A. KISHIMOTO, *J. Chem. Phys.*, 1961, 34, 393. Physical Chemistry Laboratory, Department of Fisheries, University of Kyoto, Maizuru, Japan. An empirical viscosity vs. concentration relation for concentrated polymer solutions is derived in terms of a simple free volume theory, and its applicability is tested with some available data for amorphous polymer-solvent systems. It is found that the derived relation fits well those data over the range of polymer concentrations so concentrated that interchain entanglements occur to form a weak network structure throughout the solution. In the region of relative low polymer concentrations, however, it shows deviation of a common feature from the experimental results. Authors

592. Configuration and free energy of a polymer molecule with solvent interaction. M. E. FISHER and B. J. HILEY, *J. Chem. Phys.*, 1961, 34, 1253. Wheatstone Physics Laboratory, King's College, London, England. The lattice model of a polymer molecule with excluded volume and nearest-neighbor forces arising from polymer-solvent interaction is investigated by exact numerical calculation for short chains of up to about ten links. Extrapolation to large values of n , the number of links, is shown to be justified and enables the mean configuration, free energy, entropy, and internal energy to be evaluated as functions of the number

SECTION E

of links and of temperature for both poor and "super-perfect" solvents. Numerical data and graphs are presented for the free energy, entropy, and internal energy as functions of η , the nearest neighbor interaction parameter.
Authors, abridged

593. Temperature coefficient of the polyethylene chain conformation from intrinsic viscosity measurements. P. J. FLORY, A. CIFERRI and R. CHIANG, *J. Amer. Chem. Soc.*, 1961, **83**, 1023-1026. Mellon Institute, Pittsburg, Pa. Temperature coefficients $d\ln[\eta]/dT$ are reported for linear polyethylenes in *n*-hexadecane, *n*-octacosane, and in *n*-tricontane over the range 114° to 170°C.
W.H.B.

594. Non-Newtonian flow of concentrated solutions of high polymers. II. Polystyrene in toluene. S. ONOGI, Y. KOJIMA and Y. TANIGUCHI, *J. Japan Soc. Test. Matls.*, May, 1961, 62-65. Department of Polymer Chemistry, Kyoto University, Kyoto. Log-log plots of zero shear viscosity against concentration for polyvinyl alcohol solutions consist of two straight lines intersecting at a critical concentration. The critical concentration in volume fraction, multiplied by the chain length is of the same order as the similar parameter obtained from log-log plots of viscosity vs. chain length. Similar relationships would be expected for non-polar polymers; this was confirmed for a series of polystyrenes. [Japanese, English summary]
Authors, abridged

595. Intrinsic viscosity-temperature studies of polyvinyl acetate solutions. M. R. RAO and (Miss) V. KALPAGAM, *J. Sci. Industr. Res.*, 1961, **20B**, 207-209. Intrinsic viscosity $[\eta]$ in the temperature range 30-68°C has been determined for well-fractionated samples of P.V.A. in the solvents toluene, benzene, chlorobenzene, acetone, ethyl acetate and methyl ethyl ketone.
Authors

596. Singularity in the steady flow of concentrated solution of polyvinyl alcohol. T. INOUE and O. MORIMOTO, *J. Japan Soc. Test. Matls.*, May, 1961, 60. Research Laboratory of Kurashiki Rayon Co., Okayama. An anomalous relation between viscosity and shear rate is reported for solutions of polyvinyl acetate in water or dimethylsulphoxide. [Japanese, English summary]
J.H.C.V.

597. Viscosity measurements of concentrated solutions of polyacrylonitrile in dimethyl sulphoxide by Umstatter's capillary viscometer. M. TAKAHASHI, *J. Chem. Soc. Japan, Ind. Chem. Sec.*, 1960, **63**, 2201-2204. [Japanese, English summary]

598. Solutions of acrylonitrile polymers. Part I. Dilute solution viscosities of polyacrylonitrile. Part II. Solubility of polyacrylonitrile and its related polymers. K. MIYAMICHI and M. KATAYAMA, *Chem. High Polymers (Japan)*, 1960, **17**, 672-678. [Japanese, English summaries]

599. Colloid chemistry of the system: soap-cresol-water. Part XI. Viscosity of sodium ricinoleate solutions in the presence of *o*-cresol and sodium chloride. E. ANGELESCU and G. POPESCU, *Studii si Cercetari Chim. (Bucharest)*, 1960, **8**, 565-578. [Roumanian, French summary]

600. Rheology of dispersed systems. T. NAKAGAWA, *J. Japan Soc. Test. Mats.*, May, 1961, 3-8. Department of Polymer Science, Hokkaido University. A general review of the systems used to describe the mechanical properties of highly filled disperse systems. The relation between surface properties and rheology is discussed in some detail; model materials for studying such behaviour are synthetic latexes and suspensions of ion exchange resins, since their surface conditions can easily be controlled by chemical techniques. [Japanese, English summary]

J.H.C.V.

601. Determination of thixotropic coefficient. A. DE WAELE, *J. Oil Col. Chem. Ass.*, 1961, 44, 377-381. 221, Chase Side, Southgate, London, N.14. A measure of thixotropy is proposed, which is based on an empirical measure of the build up of structure after different intervals of rest of a dispersion in an instrument described as a co-planar rotary viscometer.

W.H.B.

602. Axial migration of particles in Poiseuille flow. H. L. GOLDSMITH and S. G. MASON, *Nature, Lond.*, 1961, 190, 1095-1096. Department of Chemistry, McGill University, Montreal, Canada. Experiments with single spheres, rods and discs passed, in suspension, through a straight circular tube have shown that migration of the particles away from the walls of the tube occurs only when the particles are deformed in the shear field. (This differs from the observations of SEGRÉ and SILBERBERG (*Rheology Abstracts*, 1960, 4(2), 334) who studied uniform suspensions of rigid spheres at much higher particle Reynolds numbers.) Liquid drops are subjected to shear deformation, and the deformation of a fluid sphere is predicted theoretically from the forces involved. This theory predicts that no migration occurs with rigid spheres. Good agreement between the experimental and theoretical data is claimed.

W.G.C.

603. Effect of the exchangeability of bonding ions on the formation of thixotropic gels. A. WEISS and R. FRANK, *Z. Naturforsch.*, 1961, 16b, 71-72. [German]

604. An extrusion method for the testing of the flow properties of plastic clays. V. J. OWEN and W. E. WORRALL, *Trans. Brit. Ceram. Soc.*, 1960, 59, 285-298; discussion, 298-302. By using compressed air to extrude plastic clay through a circular orifice and then measuring both applied pressure (P) and rate of flow (D) of the clay, the flow properties of a clay paste, over a wide range of water content, were shown to depend on: the specific clay mineral, the particular ion associated with the clay, and any non-plastic substance added to, or naturally mixed with, the clay. The three parameters which conveniently express these flow properties are: the yield value, the mixed-flow range, and the final slope of the D - P curve. The variation in flow properties with variation in these parameters is reported and discussed for the different types of clay tested, viz. natural clays, mono-ionic clays, and clay-flint mixes.

D.D.

SECTION E

605. Some considerations on the measuring method of the thixotropic properties of some clay slips. K. UMEYA, *J. Japan Soc. Test. Matls.*, May, 1961, 33-37. The Institute for Chemical Research, Kyoto University, Takatsuki, Osaka. A hysteresis loop method of measuring the thixotropic properties of clay slips is described. The hysteresis area decreases exponentially with increase in water content, and also with increase in deflocculant. [Japanese, English summary] J.H.C.V.

606. Rheological properties of concentrated suspensions—particularly of barium sulphate in polyisobutylene. M. TAKANO and H. KAMBE, *J. Japan Soc. Test. Matls.*, May, 1961, 20-23. Aeronautical Research Institute, University of Tokyo, Tokyo. Viscometric measurements at very low shear rates, and low frequency dynamic modulus measurements were made on a series of suspensions of Barium Sulphate in a non-polar liquid (polyisobutene) and a polar liquid (linseed oil). The effect of minute additions of water and sodium stearate is described. Water increases the yield point and viscosity of the polyisobutene, but has no effect on the linseed oil suspensions. Sodium stearate affects the polar, but not the non-polar suspensions. [Japanese, English summary]

Authors, abridged

607. Non-Newtonian viscosity and flow birefringence of rigid particles : tobacco mosaic virus. JEN TSI YANG, *J. Amer. Chem. Soc.*, 1961, 83, 1316-1321. American Viscose Corp., Marcus Hook, Penna. The non-Newtonian viscosity and flow birefringence of TMV were measured over a three decade range of shearing stress (0.05-58 dyne cm⁻²) using Ubbelohde type viscometers. W.H.B.

608. Particle motions in sheared suspensions. XI. Internal circulation in fluid droplets (experimental). F. D. RUMSCHEIDT and S. G. MASON, *J. Colloid Sci.*, 1961, 16, 210. Physical Chemistry Division, Pulp and Paper Research Institute of Canada, Montreal, Canada. The circulation pattern inside fluid drops suspended in a liquid subjected to hyperbolic and to shear flow has been studied and compared with that predicted from a fluid mechanical theory which assumes that the drops remain spherical and that shear stresses are transmitted without diminution across the drop interface. Details of streamlines inside and outside drops and periods of circulation have been determined for a variety of liquid pairs in laminar shear flow. Impurities and surface-active agents exercise a pronounced inhibitory effect and often completely prevent internal circulation. It is shown theoretically that a viscoelastic film at the interface can reduce the shear stresses transmitted inside the drop and thus attenuate internal circulation.

609. Particle motions in sheared suspensions. XII. Deformation and burst of fluid drops in shear and hyperbolic flow. F. D. RUMSCHEIDT and S. G. MASON, *J. Colloid Sci.*, 1961, 16, 238. Physical Chemistry Division, Pulp and Paper Research Institute of Canada, Montreal, Canada. The deformation, orientation, and burst of fluid drops suspended in a liquid subjected to both hyperbolic and shear flow have been measured for a

VOL.
4
1961

large number of fluid pairs covering a wide range of viscosity ratio p . At low deformation excellent agreement with theoretical equations due to Taylor and Cerf was found. Three classes of drop behavior for large deformations in shear flow are described and are shown to depend upon p . Two of these classes lead to bursting of the drop in shear flow, and the third to an upper limit of deformation. The critical conditions of burst were shown to be in reasonable agreement with the theory. The effects of added emulsifiers and of electrostatic fields on the deformation have also been studied.

Authors

610. Factors affecting the flow properties of oil-in-water emulsions.

M. MAMOTANI and S. MATSUMOTO, *J. Japan Soc. Test. Matls.*, May, 1961, 24-26. Research Laboratory, Momotani-Juntanken, Ltd., Minatoku, Osaka. Low shear rate viscometric measurements have been made on two oil-in-water emulsions; in each the disperse phase was 20% glyceryl monostearate in liquid paraffin. The dispersion media were polyoxyethylene sorbitan monostearate (I) and sucrose monodistearate II. Emulsion I shows Newtonian behaviour at low concentrations, whereas II is non-Newtonian at all concentrations. The difference is associated with the thickness and character of the hydration layer. [Japanese, English summary]

Authors, abridged

611. Rigidity factor of gelatin gels. AUDREY TODD, *Nature, Lond.*,

1961, 191, 567-569. British Gelatine and Glue Research Association, 2a Dalmeny Avenue, Holloway, London, N.7. This investigation was designed to determine whether the unidentified structural feature of gelatin gels called the "rigidity factor" is related to chain configuration as shown by the optical rotation of the gel. Three gelatin samples of widely differing rigidity factor but of the same high molecular weight and similar chemical composition ($pl \sim 5$) were studied in neutral aqueous solution containing 5.5 gm. protein/100 ml. A single relationship exists for the gels between the specific rotation $-\alpha_D$ and the square root of the rigidity modulus, for the temperature range 0-30°C. It is concluded that the rigidity factor defines the capacity of the gelatin molecule to fold in a regular manner and, from other evidence such as X-ray diffraction, that this regular folding in gelatin gels is the same type of triple helix present in native collagen.

W.G.C.

612. Bromate reaction in dough. J. A. ANDERSON, *Proc. Roy. Aust. Chem. Inst.*, 1961, 28, 283-296. Grain Research Laboratory, Board of

Grain Commissioners for Canada, Winnipeg, Manitoba. A review of the work done in the author's laboratory to understand the physical properties of dough and its baking behaviour in terms of the chemistry and reactions of dough constituents. Rheological work with a Brabender extensograph is described.

E.R.B.

613. Rheology of "Yokan" (Pasty Food). T. MATSUSHITA, T. SAKAI

and T. NAKAGAWA, *J. Japan Soc. Test. Matls.*, May, 1961, 47-48. Eitaro Confectionery, Suginami, Tokyo. The relation between the subjectively assessed consistency, penetration behaviour on a "curdrometer" and

SECTION E

chemical constitution was investigated for a series of Yokans. Yokan is a pasty food made by gelation of concentrated starch suspension in sugar with agar-agar. [Japanese, English summary] J.H.C.V.

614. Thixotropic behaviour and crystallinity of butter. E. FUKADA, T. SONE and M. FUKUSHIMA, *J. Japan Soc. Test. Matls.*, May, 1961, 43-46. Kobayashi Institute of Physical Research, Kokubunji, Tokyo. The flow properties of butter at 20°C have been studied in a cone and plate and a parallel plate plastometer. The viscosity and yield point decrease considerably on kneading, but recover their original values gradually on standing. Dilatometry experiments over a period of two months show crystallisation behaviour on setting. It is shown that the recovery of the original flow properties can be related quantitatively to this crystallisation. [Japanese, English summary]

Authors, abridged

615. A viscometric study of the breakdown of casein in milk by rennin and rennet. G. W. SCOTT BLAIR and J. C. OOSTHUIZEN, *J. Dairy Res.*, 1961, 28, 165. Nat. Inst. Res. Dairying, Shinfield, Reading, England. When rennet acts on casein, before any aggregation, there is a marked fall in viscosity. For fat-free milk, the system is virtually Newtonian and Ostwald viscometers may be used. The viscosity fall follows a first-order equation (rate constant k_1) except when very little rennet is used when fall-rate is constant (k_0); k_0 being proportional to, and k_1 independent of substrate concentration. With pure enzyme, k_0 and k_1 are both proportional to rennin concentration. Curvature when commercial rennets are used may measure purity of rennet (not activity). Reduced viscosities are linear against milk concentration over a considerable range and accurate values of intrinsic viscosity may be calculated. It seems likely that k_1 could be used for practical tests of activity of commercial rennets. G.W.S.B.

616. Mechanical properties of the thick white of the hen's egg. Part 2. Relation between rigidity and composition. J. BROOKS and H. P. HALE, *Biochim. Biophys. Acta*, 1961, 46, 289-301.

617. Studies on the viscoelasticity of plastic fat by the use of a parallel plate plastometer. S. OKA, E. FUKADA and T. SONE, *J. Japan Soc. Test. Matls.*, May, 1961, 38-41. Department of Physics, Tokyo Metropolitan University, Tokyo. The viscosity, elasticity, yield value and retardation time of a plastic fat containing tristearin in paraffin oil were measured over the range 21° to 39°C. The results were analysed in terms of the equations of Dienes and Oka. The creep curves over a range of temperatures can be shifted along the time axis to superpose. [Japanese, English summary]

Authors, abridged

618. Mechanical properties of plastic-disperse systems at very small deformations. M. VAN DEN TEMPEL, *J. Colloid Sci.*, 1961, 16, 284. Unilever Research Laboratory, Vlaardingen, Netherlands. A system containing flocculated solid particles in a liquid shows viscoelastic behavior

at very small deformations. A model is described by means of which the elastic modulus of the system can be correlated with the forces acting between the particles. It is assumed that these forces are due to van der Waals-London attraction, and their contribution to the modulus is calculated. The energy content of the van der Waals-London bonds in materials containing fat crystals in oil has been estimated from measurements of their rate of breaking in creep experiments, to be about 40 kT -units, in satisfactory agreement with the results of stiffness measurements.

619. Colloid chemical studies of starch. Part 3. Dynamic viscosity and dynamic rigidity of starch solutions. M. NAKAGAKI and K. MURAGISHI, *Bull. Chem. Soc. Japan*, 1961, 34, 316-319.

620. Electrification and rheological properties of plastic non-aqueous dispersed systems. YU. F. DEINEGA, A. V. DUMANSKI and G. V. VINOGRADOV, *Kolloidnyi Zh.*, 1961, 23, 25. Institute of Gen. and Inorg. Chem., Acad. Scis. U.S.S.R., Kiev. Based on electro-osmosis experiments it has been shown that in plastic soap greases a double electric layer exists at the interfacial boundary, the disperse phase carrying the negative charge. A study of the electrification of a non-homogenized sodium grease was carried out in a condenser-viscometer with co-axial cylinders. At low loading rates a monotonous increase or sharp extremal changes take place in the potential of the internal lining of the condenser, depending upon the structure of the grease and the conditions of its deformation. An important part in the electrification process is played by flow in the layer adjacent to the wall. [Russian, English abstract] Authors

621. Glass transition phenomena and rheological properties of asphalt. Y. WADA and H. HIROSE, *J. Japan Soc. Test. Matls.*, May, 1961, 27-28. Faculty of Engineering, University of Tokyo, Tokyo. The glass transition temperature of asphalt is higher, and the associated volume change smaller, the higher the content of asphaltene. The time temperature superposition principle works well for all the grades studied. The characteristic temperature is invariably 56°C higher than the glass transition temperature. [Japanese, English summary] Authors, abridged

622. Viscoelasticity and critical condition for brittle fracture of asphalts. R. GORO and H. AIDA, *J. Japan Soc. Test. Matls.*, May, 1961, 29-32. The Institute for Chemical Research, Kyoto University, Takatsuki, Osaka. A material such as asphalt fractures when the deformation rate reaches critical value U_B below which the deformation is viscous; brittle fracture occurs when the stored elastic energy exceeds the energy of cohesion. The two above assumptions are combined with the basic equations for a Maxwell Body to give the relation:

$$t < 1.15\tau$$

where t is the breaking time and τ the relaxation time. For a generalised Maxwell Body the relation remains valid, where τ is the mean relaxation time associated with the critical rate U_B . High speed photographic studies of crack propagation in asphalt confirm the above relation over a limited range of temperature and composition. [Japanese, English summary] Authors, abridged

SECTIONS F AND G

Section F

LIQUIDS

623. The condensed phases of sulphur trioxide. Part I. Vapour pressure and viscosity of the liquid phase at low temperatures. R. A. HYNE and P. F. TILEY, *J. Chem. Soc.*, 1961, 2348-2352. Bristol College of Science and Technology, Ashley Down, Bristol 7. The viscosity of liquid sulphur trioxide over the range 17-50°C is related to temperature $T^{\circ}\text{K}$ by $\log_{10}\eta(cp_0) = -1.3726 - (404.82)T^{-1} + (2.6583)10^5T^{-2}$. W.H.B.

Section G

GENERAL

624. Viscous variety. P. H. STIRLING and HENRY HO, *Ind. Eng. Chem.*, 1961, 53, 56A-59A. Canadian Industries Ltd. As a means of control of manufacture on non-Newtonian fluids, single point viscometry can yield useful quality control if its limitations are understood. J.O.C.

625. Application of a theory of nonideal solutions to results of ultrasonic absorption measurements. F. O. GOODMAN, *J. Chem. Phys.*, 1961, 34, 1585. Queen Mary College, University of London, London.

626. The measurement of film elasticity. KAROL J. MYSELS, MICHAEL C. COX and JOHN D. SKEWIS, *J. Phys. Chem.*, 1961, 65, 1107. Chemistry Department, University of Southern California, Los Angeles 7, California. The elastic modulus of soap films, as defined by Gibbs, has been measured for the first time by simultaneously determining the change in the surface tension acting upon the film and the motion of the interference fringes which this produces. The experimental procedure is described in detail and its limitations are discussed. For a number of mobile films the modulus of elasticity is of the order of 10 dynes/cm² whilst for a rigid film of sodium lauryl sulphate-lauryl alcohol solution it is of the order of 100 dynes/cm. I.H.H.

627. Effective contact stresses and friction. D. H. TROLLOPE, *Nature, Lond.*, 1961, 191, 376-377. Civil Engineering Department, University of Melbourne, Australia.

628. Biorheology and microcirculation. G. W. SCOTT BLAIR, *Nature, Lond.*, 1961, 191, 757-758. National Institute for Research in Dairying, University of Reading, Berks. A brief review of the papers given at a symposium with the above title, held at Jerusalem and Rehovot in April. W.G.C.

BOOK REVIEWS

Lectures on Theoretical Rheology (Third Edition).

MARKUS REINER.

North-Holland Publishing Company, Amsterdam, 1960. xvi+158 pp. Approx. 30s.

When the first edition of Professor Reiner's book was published in 1943 under the title of *Ten Lectures on Theoretical Rheology*, materials that did not approximately conform either with Hooke's law of elasticity or with Newton's viscosity law were still something of a novelty to most scientists. Very few people indeed had considered the new concepts that would be needed to build up a theory of complicated rheological phenomena comparable with the classical theories of elasticity and hydrodynamics. The first edition was for many readers a first introduction to the basic ideas of rheological theory; it acted as a stimulus to deeper thought about rheological phenomena generally and so was undoubtedly responsible for initiating some of the rapid growth of theoretical rheology that we have seen during the post-war years. However, the reader of the third edition looking for an indication of the scope of recent developments in this field will be sadly disappointed.

The fifteen *Lectures* are to be regarded as giving an elementary introduction to theories of deformation and flow for the student with a mathematical bent. They introduce in turn the fundamental need for separating the motion as a whole in space and the deformation (relative motion of the parts) of a material element, the concepts of strain and of stress and the existence of a relation between them—a rheological equation of state. The use of Cartesian and cylindrical coordinates, the usefulness of Cartesian-tensor representations, principal stresses and the Mohr-circle diagram, some simple forms of the equations of motion (or of equilibrium) with the stresses eliminated, the ideas of dimensional analysis and rheological similarity, and the treatment of some simple deformations and flows that will be familiar to anyone who has studied elasticity theory or hydrodynamics, all find a place amongst descriptions of some of the simpler non-Hookean, non-Newtonian bodies.

Equations of state are constructed to represent stress relaxation and delayed elasticity (linear differential equations associated with the names of Maxwell and Kelvin), and the type of plastic flow associated with the name of Bingham. A brief indication is included of some non-linear equations of state, leading to the "cross-viscosity" and "cross-elasticity" effects that have been frequently observed. The microscopic or molecular causes of rheological complications and the spring-dashpot model representations of linear viscoelastic behaviour are the subject of one lecture. It is emphasized that there is need for discussing departures from ideal elasticity even in a change of volume without change of shape, and for discussing mechanical failure when the strength of a material has been surpassed either in shear or dilatation.

There is certainly enough here to whet the student's appetite for more and it is to the student who is prepared to read elsewhere for further details and clarification that the book will be most valuable.

J. G. OLDROYD

Mechanics of Solids and Fluids.

ROBERT R. LONG.

Prentice-Hall, London, 1961. x+156 pp. 45s.

The author of this book, who is Professor of Fluid Mechanics at the Johns Hopkins University, has succeeded well in producing a unified treatment of continuous media with emphasis on the rigorous development of the equations of motion of elastic solids and Newtonian fluids. The volume is unusual, but very welcome, in presenting a parallel treatment of the theories of solids and fluids and will form a valuable addition to the literature on the subject and be of particular interest to postgraduate students.

The mathematical technique used to develop the theory is that of Cartesian tensors, accompanied by the usual notations, which leads to a very compact treatment. This does, however, seem to require a maturity of mathematical ability rather in excess of the knowledge of "elementary differential and integral calculus" which the author claims is all the mathematics required to read the book—the word "elementary" has, of course, relative qualities!

Although Professor Long has been able to teach the subject successfully by this approach to undergraduate engineering students it must, I think, be said that the book would not normally be regarded as suitable for undergraduate study in this country.

After a very easy to read chapter on vectors and tensors and a discussion of the properties of materials, the book is divided equally between the study of solids and fluids. Chapters developing the theory are in each case followed by a chapter of worked problems which are generally of an elementary character. Problems are given at the end of each chapter for further study, together with many references for further reading.

D. E. R. GODFREY

Printing Inks and Color.

Edited by W. H. BANKS.

Pergamon Press, Oxford, 1961. xiv+352 pp. 80s.

The present volume is the first of a new series *Advances in Printing Science and Technology* and is, in fact, a report of the Proceedings of the Fifth International Conference of Printing Research Institutes held at the National Printing Ink Research Institute, Lehigh University, in 1959,

VOL.
4
1961

DL.
4
961

under the chairmanship of Professor Zettlemoyer, Director of NPIRI. Reports of previous conferences have appeared in the *International Bulletin for the Printing and Allied Trades*, but this is now inadequate and we presume future conferences will also be reported in book form.

The subject matter of the Fifth Conference papers is fairly evenly divided between the measurement of colour and investigations of other properties of printing inks. Rheological concepts of one kind or another are implicit in all discussions of printing and it is to be hoped that some day an authoritative and comprehensive survey of the whole subject from an explicitly rheological point of view will be undertaken. The present volume does not attempt to do this but does, in fact, indicate the approach being made to some of the major rheological problems by about twenty National Institutes plus some of the larger private industrial research organisations.

The rheological problems in all cases are tackled empirically rather than theoretically, and the field covered will be apparent from the following items.

Various aspects of the measurement of tack, but not its fundamental nature, are discussed in papers from PATRA, the Lithographic Technical Foundation, FOGRA and the Hungarian Institute; the rheology of ink transfer and distribution is discussed in papers from PATRA, NPIRI, LTF, and the American Newspaper Proprietors' Association Research Institute; apparatus for measuring pressures and the observation of film thickness in actual printing are also described; the rheological behaviour of inks in tension is discussed for the first time.

The papers vary considerably in quality as might be expected from their diverse origins. Most papers have abstracts and discussions, the latter showing evidence of considerable powers of compression on the part of the editor. Printing and binding, the latter being particularly attractive, are excellent, and misprints are few and unimportant.

This first volume of *Advances in Printing Science and Technology* adequately illustrates the large volume of scientific work now being done on a subject which did not even exist thirty years ago. R. F. BOWLES